LEPROSY

BY

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THIRD EDITION

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PREFACE TO THE THIRD EDITION

In the bombing of Bristol a large part of the second edition was destroyed This accounts for the appearance of a third edition only some six years after the last whereas there was an interval of fifteen years between the first two editions

Additions have been made to the sections entitled Prophylaxis, Aetiology Clinical and Treatment Many of the illustration blocks were destroyed and new ones have been added making now eighty-eight in all

A bibliography has been appended giving a list of books conference reports and papers referred to in the text Some of these papers are summaries which themselves have extensive bibliographies on various aspects of leprosy such as McKinley on bacteriology Dharmendra and Lowe on the lepromin test, Villela on blood chemistry It should thus be easy for those with recourse to recent journals on leprosy to supplement the necessarily brief accounts given in this text book.

During the second world war progress in our knowledge of leprosy and in its control in endemic countries has inevitably been handicapped but in spite of this definite progress has been made in the last six years Special reference should be made to the work on the lepromin test, the relationship of the two main types to one another and the testing of new drugs.

Much still remains to be discovered about the transmission of leprosy but it is generally accepted that close contact promotes its spread Improved communications by air road and sea have brought people of different races and social levels into closer contact with one another thus

increasing the danger of transmission There are however, signs that both the public and those in authority are taking a keener interest in this disease as it becomes increasingly a matter of concern to all

This book seeks to give in short and concise form the fundamental knowledge of the subject required by doctors and others engaged in anti leprosy work, and to set forth the problems requiring solution if final control of leprosy is to be secured

We wish once more to acknowledge with gratitude the great help given and the personal interest taken by the publishers

L. R.
E. M.

LONDON
January 1946

PREFACE TO THE FIRST EDITION

THE Leprosy problem has baffled medical science for over three thousand years in the absence of any curative treatment but now that effective methods are available of clearing up the symptoms and infectivity of most early and some more advanced cases, the whole question has entered on a new and more hopeful epoch and requires reconsideration in the light of our present knowledge.

Fifty years ago the discovery of the lepra bacillus by Hansen threw a flood of light on the aetiology of leprosy and revolutionized our entire conception of its epidemiology by displacing the then dominant and paralysing hereditary theory of its origin by the now generally accepted and more hopeful infective one. The precise mode of communication, however is still unproved necessitating a close study of all the relevant facts recorded in the vast literature of the subject to enable a firmly based system of prophylaxis to be formulated Moreover the incidence of the disease and the conditions favouring its prevalence and spread vary so widely in different parts of the globe that a comprehensive study of the distribution of leprosy is essential to an understanding of the many difficulties to be overcome in dealing with this world wide scourge.

In the present work an attempt has been made to summarize the most important previous literature having a practical bearing and to give a clear clinical account of leprosy and its treatment, based on a large personal experience with especial attention to the early and more amenable stages which we hope will prove of service to workers in affected countries One of us (L. R) is mainly responsible for the first three sections on the history and distribution, epidemiology and prophylaxis and the other (E M) for those on aetiology clinical description and treatment but each has had the

benefit of the other's help under the limitations imposed by our collaborating at a distance of several thousand miles which we trust will be some excuse for the inevitable short comings of this work, which will not be in vain if it should succeed in arousing renewed interest and stimulating greater efforts to utilize our present knowledge more effectively than hitherto in the task of controlling and reducing the most cruel disease that flesh is heir to

We are indebted to the Indian Research Fund Association, and to Messrs Thacker Spink & Co of Calcutta, for the loan of some blocks of illustrations from Dr Muir's papers in the *Indian Journal of Medical Research*, and to Dr E. Landeman for his assistance in revising the manuscript of the last three sections We regret that the report of the Strasbourg Leprosy Conference appeared after our work was in print

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L R.
E M.

LONDON
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Section I—HISTORY AND DISTRIBUTION

CHAPTER I

HISTORY OF LEPROSY

Ancient History.—The origin of leprosy is lost in the mists of antiquity although some of the oldest known records refer to skin diseases which have been thought by some to refer to this disease. These include an Egyptian record of 1350 B.C. in the reign of Rameses II among negro slaves from the Sudan and Dafur to the south of Egypt but this reading has been disputed, and Ruffer found no evidence of the occurrence of the mutilations of leprosy among large numbers of mummies examined In India the term kushtha occurring in the Vedas of 1400 B C. is also believed by some to relate to leprosy but as neither loss of sensibility nor deformities are mentioned this reading is also doubtful Similarly in China it has been suggested that leprosy was probably present 5000 years ago in the time of Confucius, and a good description of the disease is found in a work of about A.D 610 according to Huizenga (1934)

Biblical Leprosy.—There has been much controversy regarding the true nature of Biblical leprosy The description of the disease as highly contagious yet readily curable and producing the appearance of white as snow is very far from being correct as applied to leprosy as we now know it It is generally agreed that the zaraath of the Bible included a number of skin diseases such as psoriasis as well as leprosy Dubruilh and Bargues explain that the 70 learned men of Alexandria, in 150 B C. in translating the sacred writings into Greek used for zaraath the Greek word lepra then having the Hippocratic signification of scaly disease Later when true leprosy reached Greece it was known among them as elephantiasis and in the tenth century the Arabian scholar Constantine, of Carthage originated and perpetuated the mistake in

FIGURE

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Section I—HISTORY AND DISTRIBUTION

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his medical writings by wrongly translating the Arabic word for true leprosy djudsam into the word lepra MacEwen and Unna contended that zaraath implied taboo rather than a definite disease but Jeanselme rejected that theory and concluded that the term did not simply mean leprosy but included various skin diseases such as leucoderma with depigmented patches of skin, psoriasis eczema, lichen, etc. improvement in which might take place during the few days intervals between the examinations by the priests enjoined in the book of Leviticus. Cases of leprosy may possible also have been included under the term.

The Spread of Leprosy over Europe.—According to Munro, Hippocrates writing about 400 B C. did not describe leprosy but Aristotle did so about 345 B C. so it was then present in Asia Minor and on the Greek coast as a still rare disease and it probably became common about 200 B C. Up to the conquest of Egypt by Cambyses in 525 B C. that country was closed to the Greeks soon after came the conquest of Darius, and in 480 B.C. that of Xerxes, who according to Herodotus led six million people into Europe from all the nations of Asia and Africa under his rule and left thousands behind him when he retired this would account for the introduction of leprosy into Greece with a slow spread at first.

The further progress in Europe can be traced Leprosy was unknown in Italy until the return of Pompey's soldiers from the East in 62 B.C. Galen wrote of the disease in Germany in A.D 180 and four centuries later it had become so common and widespread that, according to Virchow there were then 696 leper houses in Italy Verdun and Maestricht. In the fifth and sixth centuries Spain was infected by Roman troops and it was common there by the tenth century after the fall of Rome the conquests of Alaric and others further disseminated the disease. About forty years after the Saracens from Spain invaded France, Pepin (in A.D 757) issued a decree making the marriage of lepers illegal and the disease a cause for divorce. Two centuries later it was common in France, having been introduced in the seventh century into the Pyrenees whence it spread north (Durondie) G Newman states that the first known leper hospital in England was established in Nottingham in A.D 625 or 638 and in Ireland there was almost certainly one in 869 James Y Simpson, of Edinburgh showed that leprosy had reached Wales by 950 when a law similar to to Pepin s was passed. In 1101 a leper house was founded at St Giles, near London (Jeanselme) Newman, however says leprosy was not very prevalent in Scotland before the fourteenth

century although Munro gives the date of the first leper house north of the Tweed as 1177 There was one at Bergen, in Norway in 1266 as at the present day The disease was probably carried there from Scotland whence it also spread later to the Shetlands, Faroe Islands Iceland and Greenland St. Kilda is said to have been infected only in 1680 Holland, Denmark, Sweden and more accessible parts of Russia on the Baltic and the Black Sea also suffered from leprosy which was known as early as 1256 in the Crimea there a Greek colony had been founded in 550 B.C. and later much commerce passed through it

The Influence of the Crusades of 1095 to 1270 on Leprosy in Europe.—Although it is quite certain that practically all parts of Europe, including most of what is now the United Kingdom except the more remote parts of Scotland were affected with leprosy long before the Crusades of the end of the eleventh and during the twelfth and thirteenth centuries yet, according to Leloir and Lavernq the disease became more widespread and alarming in Western Europe at this period.

The Degree of Prevalence during the Middle Ages in Western Europe—This is difficult to estimate and has been the subject of much controversy largely based on the number of leper houses and cases in them of which any record has survived Exaggerated statements regarding the number of leper houses, such as 2000 in France have sometimes gained credence but have been discredited by Jeanselme who estimated that there were 59 in the diocese of Paris and 218 in the whole of Normandy and that they rarely held over 12 and often only a very few cases. In England Sir James Simpson compiled a list of over 100 leper houses, but MacArthur (1925) shows clearly from an examination of the old records that many of these never contained any leprosy patients others had only very small numbers in addition to a larger proportion of poor and other non leprous persons. He quotes and agrees with the following estimate by Creighton of the extent of leprosy in England in the Middle Ages at its worst period

There might have been a leper in a village here and there one or two in a market town, a dozen or more in a city a score or so in a whole diocese Thus in the records of the city of Gloucester under the date 20 October 1273 three persons are mentioned by name—a man and two women—as being leprous and as dwelling within the town to the great hurt and prejudice of the inhabitants The great dread of the disease in those days which indeed exists to the present day doubtless led to exaggeration regarding its prevalence.

The Decline of Leprosy in Europe.—The rapid decline of leprosy in Europe during the fourteenth and fifteenth centuries is perhaps the most remarkable feature in the long history of the disease Regarding its causes there has been much controversy largely influenced by the contagionist or anti-contagionist views of the writers, mainly in the days before the bacillus of Hansen was discovered and generally recognized as the cause of leprosy The facts, however, are clear for in England the disease had begun to decline in the fourteenth century and had nearly disappeared by the end of the sixteenth century a Royal Commission in 1547 reported that most of the leper houses were then empty Cases persisted in Scotland and Cornwall, which were last affected, and leprosy remained more or less endemic in Ireland up to 1775 and in the Shetlands up to 1798. In France it was still common at the end of the sixteenth century and died out in 1789 in 1695 leper houses were abolished by Louis XIV as no longer required. A few cases still remain in the Maritime Alps in the south to the present day In Germany it was still common, although dying out, in the middle of the sixteenth century at which period it ceased in Denmark. It died out of the Netherlands in the middle of the seventeenth century but remained common in Sweden to the beginning of the nineteenth century and still occurs in small areas of that country The disease also declined in Spain and Portugal, although it is still fairly frequent in those countries. In the middle of the nineteenth century it was widespread and apparently increasing in Norway where the diet and state of civilization were then behind those of most of Western Europe. It still prevails in the Baltic Provinces southern parts of Russia, and in Turkey

Leprosy Prophylaxis in the Middle Ages and Its Influence on the Prevalence of the Disease.—Here again opinions differ regarding both the extent of prophylactic measures and their share in bringing about the reduction of leprosy in Western Europe above recorded. Jeanselme described the ceremonies carried out in France and Flanders on the discovery and isolation of a person affected by leprosy as differing but little from the burial service they included sprinkling earth on the head of the leper to signify that he was buried from the world. He was then supplied with a special garment and with clappers to warn the healthy from approaching him too closely and he was taken to live in a hut in the fields outside the village or town or to a leper house. He was forbidden to have a wife to touch infants or young persons or to eat or drink with companions other than lepers. He also recorded the significant rule that if a healthy person resolved to continue to

live with an infected spouse the above service was held over both and that it was necessary to separate from them any infants born to them if the latter showed no sign of the disease an important precaution observed even at the present day This authority points to a letter of 1371 recording that lepers circulated with impunity in town and country in spite of injunctions and threats of the authorities Nevertheless Jeanselme concluded that the retrogression of leprosy in Europe was in large part due to prophylactic measures and not due to acquired immunity or decreased virulence because the disease continued unabated where no prophylactic measures were carried out He also pointed out that somewhat similar but more humane, isolation measures proved effective during the later part of the nineteenth century in Norway The contagionist Munro and others agreed with this view but non-contagionists such as Hutchinson and Newman denied any influence of Middle Ages segregation in reducing leprosy in Western Europe, on the ground that not all the lepers were isolated and that they were allowed to beg in towns, so the conditions were not such as would prevent the spread of a contagious disease. Moreover in England MacArthur found no evidence of the enforcement of the severer measures used in France for at any rate subsequent to the Norman conquest, there has been no law in this country to sanction the divorce of a leper from his wife or to deprive him of his property and civil rights, and he has recorded evidence to the contrary effect Vandyke Carter with an open mind on the contagiousness of the disease, allowed most weight to the vigorous prophylactic measures adopted to check the progress of the disease and also some influence to improvement in the diet and habits of the people he pointed out that in the East in the absence of such prophylactic measures the disease is as rife as ever

In forming conclusions on this debated point recent experience must be taken into account On the one hand, the fact that long-continued residence in the same house with an infective leper is the most frequent cause of infection indicates that enforced residence of the few infective cases outside a town or village must have played some part in the reduction of new infections On the other hand compulsory powers even yet often fail to discover and isolate cases before they give rise to new infections, and would scarcely have been more effective in early days such failures must have greatly reduced the efficiency of prophylaxis during the Middle Ages which cannot therefore be credited with being the sole cause of the definite decrease of leprosy in Europe from the fourteenth to the sixteenth century

Influence of Improved Diet and Living Conditions on the Decline of Leprosy—It is shown later (p 53) that a deficiency in diet especially in vitamins, predisposes to leprosy infection It is therefore very significant that the end of the fifteenth and beginning of the sixteenth century marked the end of the Dark Ages when vegetables including potatoes, became common in England and led to a decreased consumption of salted meat, fish and black rye bread, which formed the staple diet in the fourteenth century sanitation also began to improve (Newman) Moreover a general improvement in the conditions of living especially in housing accommodation was doubtless an important factor in reducing the overcrowding so favourable to house-contact infection. That a high degree of civilization is inimical to the spread of leprosy is indicated by the practical absence of infection from imported cases in Great Britain, France and the temperate areas of the northern United States of America (p 42) Moreover endemic leprosy has persisted in Norway Sweden Spain Portugal, the Maritime Alps of France and Italy as well as in Eastern Europe where less advanced social conditions remained up to recent times. Further the disease has continued for probably several thousand years in Africa India and China, where so many families still reside in one-roomed huts Thus improved diet and living conditions may well have been the main factor in the decline and disappearance of leprosy as an indigenous disease from north-western Europe.

Another factor which may well have played a part in the rapid decline of leprosy in England in the latter part of the fourteenth century was the black death in 1349 which is supposed to have destroyed not much less than one half of the population in such a terrible time the poor helpless lepers must have suffered even more severely than the general population.

Spread to the Western Hemisphere.—At the same time that leprosy was declining rapidly in Europe it was carried to the Western Hemisphere with the discoveries of the West Indian Islands and the American continent. Authorities are practically unanimous that the aboriginal Indians of the Western Hemisphere were free from the disease before Europeans arrived there even to the present day the more savage tribes, who have held themselves aloof from close intercourse with European, African and Asiatic immigrants, have remained free from leprosy although others coming into close contact with leprosy infected races have frequently been attacked (Munro Leloir Hillis etc.)

The earliest European discoverers and immigrants came from Portugal and Spain at a time when leprosy was widespread among

them There is clear evidence that they carried the disease to America with them for Montaya stated that as early as 1543 all the first cases in Colombia were in Spaniards chiefly from the southern Andalusian province. Solano said it was imported by the discoverers of Colombia, as shown by the fact that historians of the conquest do not mention leprosy among the indigenous inhabitants and it is still absent from the more isolated savage tribes of Central America. Seidl recorded its introduction into Brazil by the Portuguese colonists and that there is a tradition that Cuba was infected in the middle of the eighteenth century by a Spanish family from Valencia (Duque) In favour of the contrary view it has been said that Cortes founded a leprosarium in Mexico soon after his arrival but it has been pointed out that it was much more likely to have been a hospital for his men attacked with syphilis, and Gutierrez Lee in the course of a profound study of the subject found no evidence in favour of any such statement

A more important factor in the spread of leprosy in the Western Hemisphere was undoubtedly the African slave trade most of these involuntary immigrants came from the leprosy infected central areas of the Dark Continent. According to Ehlers leprosy was spread widely by the African slave trade, which was begun in the West Indian island of San Domingo as early as 1500 fifteen years before the discovery of the American mainland. In the last twenty years of the seventeenth century 300 000 negroes were transported to Jamaica alone leprosy being an important disease among them Montaya estimates the numbers carried to Central America by the end of the sixteenth century to have been 1 300 000 many of these landed at Carthagena in Colombia and spread leprosy rapidly

Drognant Landré gives an interesting account of the origin of leprosy in Dutch Guiana (Surinam) which was first colonized by about sixty English in 1630 In 1644 Portuguese Jews came from Brazil bringing slaves with them By 1665 African slaves were imported for the plantations and the disease increased so rapidly that by 1728 an ordinance was passed forbidding lepers going into the streets of the town In 1763–4 the importation of lepers was forbidden in spite of this a further increase and the infection of whites led to a segregation measure being passed in 1790 Kermorgant records the introduction of leprosy through African slaves into French Guiana in the second half of the seventeenth century Munro states that negroes introduced the disease into Mexico Brazil, New Granada Parana, Uruguay and Venezuela which are just the countries where most slaves were imported There is also

evidence that hasty emancipation of slaves interfered with control measures against the spread of leprosy in Guiana and other American countries, leading to an increase of the disease.

The countries of America to the north of Mexico appear to have become infected later than more southerly areas. White placed the first known cases in Louisiana in the south of the United States as occurring in 1758 he thought the disease was probably imported from infected West Indian islands and not from New Brunswick as held by some This small outbreak appears to have died out, as the next authentic cases occurred in 1866 among French immigrants (p 65) and the disease has continued to the present day Leprosy appeared early in the New Brunswick province of Canada, possibly in 1758 but the first certain case was found in 1815 in a woman of French origin (p 37) - this focus still persists to a slight extent. In the latter part of the nineteenth century a number of Norwegian lepers settled in the North-Central United States in Minnesota and neighbouring States, but the disease largely died out in this healthy and civilized area (p 42) On the other hand, California and some other parts of the U S A. have been infected by Chinese and Indian immigrants these also carried the disease to British Guiana and other parts of the Western Hemisphere after the abolition of the slave trade had led to the extensive importation of leprosy affected Asiatic races

Recent Spread of Leprosy in Oceania.—During the latter part of the nineteenth century outbreaks of a startling nature took place in certain islands in the Pacific. The most important of these was in the Hawaii or Sandwich Islands, where according to Hillebrand it was probably introduced by the Chinese in 1848, since he saw the first indigenous case five years later but this origin has been disputed by other writers The next serious outbreak was in New Caledonia, where it has been shown by Grall that the disease was brought by a Chinaman who died about 1865 after two years sojourn with a certain tribe, a mem ber of which was attacked only a year later and died in four years, followed by two others who died within three years this revealed an acute type of the disease. The disease spread so alarmingly that, according to Ortholon ten years later from one fourth to one half of the population were attacked in some places, and by 1910 no less than 90 per mille, one of the highest rates on record of the convict population of 8000 had become infected The epidemic next spread from New Caledonia to the neighbour ing Loyalty Islands the first case was reported in a Chinaman in 1878 and by 1909 Nicholas found 35 per mille infected and

many cases were hidden The French Marquesas Isles were also very severely attacked In 1903 the rate per mille reached the serious figure of 66 7 according to Buisson, who thought the disease in this instance was present before the Chinese came The Nauru Island epidemic of the present century is a similar occurrence (pp 35, 137)

The history of leprosy on the Australian continent has been closely studied by Ashburton Thompson He obtained no history of the disease in the aboriginals in the primeval state but a few cases have occurred in those who have been in contact with affected Malay and Chinese races. In semi tropical Queensland and northern Western Australia leprosy occurs in the aboriginals, immigrant Chinese and in the Kanakas from Pacific islands who work on the sugar plantations A few whites have become affected in both Queensland and New South Wales, but not in Victoria south of 35 latitude Some Chinese working on the Victoria gold fields suffered but many of them were repatriated by their countrymen

The extensive spread of leprosy by Chinese immigrants was stressed by Cantlie (1897) and by Jeanselme (1902) The former recorded that they carried the disease to Indo-China, Siam, Straits Settlements Java, Sumatra Borneo the Philippines, and other East Indian islands, in several of which countries Chinese still form by far the majority of the infected

* * * * *

Thus the whole history of the spread of leprosy over the globe is one long record of affected persons carrying it to countries previously free As a rule it increases very slowly and insidiously at first and takes from one to several decades before it attracts general attention. The only countries from which it has disappeared as an indigenous disease after being firmly established have been those in the temperate zone of Europe in which severe repressive measures were enforced and were aided by great advances in nutrition sanitation and general civilization

The estimated figures for some of the countries are conservative ones for instance recent evidence seems to indicate that there are more than 1 000 000 lepers in India and more than 400 000 in Nigeria.

RELATION BETWEEN HIGH LEPROSY INCIDENCE AND DAMP HOT TROPICAL CLIMATES

The most striking fact brought out by the map and table is that every country with the very high rate of 5 per mille and over is situated within the tropics they practically all have high annual rainfalls producing a hot damp climate Such tropical countries are mainly inhabited by coloured races in a low stage of civilization living in primitive small generally one roomed overcrowded houses—all conditions very favourable to the spread of the disease. The broad tropical belt also includes most of the extensive areas showing the comparatively high rates of 1 to 5 per mille. Many of the highly infected areas are small colonies in Oceania with few inhabitants. The largest numbers of leprosy cases are found in the extratropical but hot, portions of Northern India and of Southern China, with very dense populations but only moderate leprosy rates per mille Tropical Africa also has large numbers of cases owing to the exceptionally high rates per mille in that area

Areas of the Highest Leprosy Incidence.—There are several fairly well-defined regions of high leprosy incidence.

1 *Tropical Africa* —The tropical belt of Africa shows the highest rates per mille over extensive areas in the world although owing to the scanty population the total numbers of cases may be less than in India and China. Thus, the estimated rates per mille of population are 20 in Belgian Congo 16 in French Equatorial Africa, 12 in Sierra Leone, 10 in British Nigeria, 5 4 in Uganda and 5 in Rhodesia, the Gold Coast and the Cameroons all areas with the heavy rainfall of 30 to 60 or more inches a year More over 3 to 5 per mille are met with in Mozambique, Angola, and Zanzibar also with high rainfall

2 *Tropical Asia and Oceania* —A second belt of high prevalence occurs in tropical Asia and Oceania with rates per mille of 2 in the Dutch East Indian Islands, 2 7 in the Philippine Islands 2 in Siam 13 in Fiji 3 7 in Hawaii and 30 per mille in the French Oceanic islands. These tropical areas have the very high rainfall of 60 inches and over annually

3 *West Indian Islands and the North of South America* —The third tropical belt of high leprosy is situated in the Western Hemisphere, with rates per mille of about 1 in some of the West Indian islands

from 2 to 10 or more in Guiana, 3 75 in Colombia, and between 1 and 2 in Venezuela and Brazil also all areas of high rainfall as shown in *Map II* with a hot humid climate like the other belts above dealt with

Low Incidence of Leprosy in the Subtropical Zone from 23½ to 35 Latitude.—The subtropical zone, although widely infected with leprosy presents a great contrast to the tropical one in showing few places with rates of over 1 per mille. The most important exceptions are parts of India and China and the southern portions of Japan areas with comparatively high rainfall The dry extratropical areas of North-West India, Western Asia, Northern and Southern Africa and Australia in the Eastern Hemisphere and the subtropical belt of North and South America nearly all have leprosy rates below 1 per mille these zones have a lower rainfall than the tropical one as seen from *Map II*

Incidence of Leprosy in Temperate Climates in Higher Latitudes than 35 —These include Europe and the northern parts of Asia and America in the Northern Hemisphere, but only a small area of South America, regarding which we have no definite data in the Southern Hemisphere. In no part of these zones is the high rate of 1 per mille now met with except in part of Japan which has the high rainfall of between 30 and 60 inches a year

The world wide relation between high rainfall and high leprosy incidence is much enhanced by the further remarkable fact that leprosy is nearly or completely absent from just those parts of the tropics whose annual rainfall is less than 10 inches, giving rise to a very hot dry climate namely French Mauritania to the west of the Sahara Desert what was formerly German South-West Africa and the arid South American west coast areas of Peru, Bolivia, and northern Chile

India and Burma, with their census figures of the lepers and their extremely varied rainfall afford a unique field for more detailed study of this question Rogers (1923) published a map illustrating in a striking manner the cl[illegible] p between rainfall and humidity and leprosy [illegible] ich was pointed out by the Indian Leprosy [illegible] Thus the [illegible]ively high Indian leprosy rates of o[illegible] r per met with in the wet areas of Burma [illegible] C[illegible] Eastern Central [illegible] the H[illegible] very wet [illegible] of India [illegible] of high [illegible] into Deccan and B[illegible] oldest [illegible] of India [illegible] hand [illegible] 15 per

Table I—Leprosy Incidence for Various Countries of the World

No.	Country	Authority	Year	Per Mille	Estimated	Known	Isolated
	Europe						
1	Iceland	Kleineyer	1932	0·26	—	25	—
2	Norway	Lie	1931	0·032	—	68	41
3	Sweden	Kleineyer	1933	0·003	—	31	19
4	Finland	Kleineyer	933	0·01	—	34	27
5	Estonia	Paldrock	1928	0·21	—	233	213
6	Livonia	Jeanselme	1922	0·12	—	219	210
7	Lithuania	Jeanselme	927	0·01	—	17	15
8	Russia	Vladimirov	1926	0·09	0,000	3,000	—
9	Romania	Gehr	1941	0·03	550	110	—
10	Cyprus	Muir	1910	0·64	300	228	188
11	Greece (with Crete)	Gehr	194	0·12	—	758	519
12	Yugoslavia	Gehr	941	0·04	—	503	75
13	Italy	Range	930	0·0	—	391	—
14	Malta	Araujo	1926	0·39	—	87	64
15	Spain	Gehr	1941	0·09	2 250	9 8	106
16	Portugal	Vieira	1939	0·50	—	3,000	—
	Africa						
17	Morocco	Colombani	1925	0·90	3,000	302	—
18	Algeria	Montpellier	1923	0· 2	750	150	—
19	Tunis	Conseil	1926	0·15	300	60	—
20	Tripoli (Libya)	Aldomei	1911	0·40	400	81	—
21	Egypt	Dalgamound	19 8	1·90	15,000	—	—
22	Anglo-Egyptian Sudan	Annual Report	1935	1·84	10,711	8 461	2,698
23	Abyssinia	Féran	1930	1·01	5,500	—	50
24	Eritrea	Talotta	1932		2 755	555	—
25	British Somaliland	Muir	1938	0·58	200	—	43
26	Uganda	Cochrane and Muir	1938	5 40	20,000	—	1 469
27	Kenya	Muir	1938	1 13	4,000	—	263
28	Tanganyika	Cochrane and Muir	1938	2·35	12,000	—	3 147
29	Zanzibar	Cochrane and Muir	1938	3·50	750	—	115
30	Mauritius	Cochrane	1938	5·60	2,250	450	40

(Continued on next page

Table I—LEPROSY INCIDENCE FOR VARIOUS COUNTRIES OF THE WORLD—*continued*

No.	Country	Authority	Year	Per Mille	Estimated	Known	Isolated
31	Madagascar	Abbatucci	1926	1·70	6,000	—	2,306
32	Mozambique	Cochrane	1928	4·67	14,000	7,000	500
33	Nyasaland	Muir	1940	1·00	1,600	506	396
34	North Rhodesia	Muir	1940	3·00	6,750	—	185
35	South Rhodesia	Moiser	1939	5·36	6,500	—	913
36	Swaziland	Cochrane	1928	11·70	200	—	—
37	Basutoland	Strachan and Germond	1937	2·00	1,000	—	669
38	South African Union	Annual Report	1936	0·69	—	6,767	2,263
39	Bechuanaland	Dyke	1934	0·25	50	25	—
40	Angola	Cochrane	1928	3·00	12 000	—	—
41	Belgian Congo	Commission	1939	20·00	200,000	60,565	17 983
42	French Equatorial Africa	Robineau	1924	16·10	52,000	—	—
43	French Cameroons	Jeanselme	1934	3·00	10,000	—	—
44	Nigeria	Muir	1940	20·00	400,000	—	5,022
45	Gold Coast and Togoland	Muir	1936	5·55	20,000	4,000	400
46	Sierra Leone	Muir	1936	12·00	18,000	3,656	11
47	French West Africa	Robineau	1937	2·66	—	40,000	—
	ASIA						
48	Palestine	Canaan	1937	0·11	100	—	33
49	Turkey	Cochrane	1928	0·04	600	—	—
50	Syria	Araujo	1929	0·07	250	—	50
51	Iraq	Araujo	1929	0·12	300	—	45
52	Persia	Hoffman	1936	0·08	1,000	—	350
53	India and Burma	O.A.B.H. Report	1941	3·40	1 200,000	147,911	14,000
54	Ceylon	De Simon	1939	0·70	—	3,648	1,031
55	Straits Settlements	Araujo	1926	0·96	1,200	—	740
56	Federated Malay States	Araujo and Green	1927	0·80	1 600	—	818
57	British North Borneo	Cochrane	1929	1·90	500	50	—
58	Dutch East Indies	Sitanala	1926	2·00	100,000	—	4,303
59	Philippine Islands	Haselmann	1938	2·71	40,000	—	6,984
60	Siam	Vallabhakara	929	2·00	20,000	—	660
6	French Indo-China	Audibert	926	1·50	30,000	—	5,454

62	China	Maxwell	1933	[illegible]	[illegible]		
63	Formosa	Guthrie-Taylor	1929	1·00	4,000	—	—
64	Korea	Mackenzie	1936	0·95	20,000	—	6,000
65	Japan	Papellier	1912	1·91	102,585	11,261	4 698
	Oceania						
66	Queensland	Annual Report	1931	0·32	315	—	63
67	New South Wales	Annual Report	1935	0·03	95	—	19
68	Fiji	Austin	1936	13·90	2 775	—	702
69	New Guinea	Cilento	1937	5·00	2 500	500	—
70	Nauru Island	Clouston	1936	50·00	—	159	57
71	British Solomon Islands	Innes	1938	10·20	900	221	18
72	French Oceania	Jeanselme	932	30·1	—	2,024	—
73	Hawaii	Araujo	1925	5·68	—	1 180	—
	America						
74	Canada	Page	1929	0 002	—	20	—
75	United States	Hopkins and Araujo	929	0·02	1,865	718	373
76	Mexico	Urueña	1936	0·24	3,882	—	—
77	Cuba	Setién	1935	0·57	2,000	—	387
78	Haiti	Klingmuller	928	0·43	1,000	200	—
79	Porto Rico	De Borno	1928	0·31	400	137	60
80	French West Indies	Jeanselme	1934	1·90	—	850	—
81	Jamaica	Muir	1943	0·61	1 000	—	172
82	Leeward Islands	Medical Report	1937	7	300	164	75
83	Windward Islands	Medical Report	1937	0·32	200	—	56
84	Barbados	Medical Report	1935	0·85	200	58	76
85	Trinidad	Muir	1942	2·22	1,000	—	399
86	Panama	Hurtwitz	1936	2·73	300	—	108
87	Colombia	Browning	935	3·73	30,000	—	7,059
88	Venezuela	Browning	1935	1·67	3,000	—	300
89	British Guiana	Muir	1942	3·0	1,000	900	400
90	Dutch Guiana	Lampe	1932	6·75	1,500	1 107	490
91	French Guiana	Camoune	1929	14·70	1,000	490	140
92	Brazil	Araujo	1936	1 10	48,440	30 750	11,835
93	Paraguay	Browning	1935	4 44	4,000	—	—
94	Uruguay	Browning	1935	0·33	500	—	—
95	Argentina	Susini	1935	0·62	7,500	2 989	—

are met with in the very dry hot North West areas of the Punjab Rajputana, Sind and in Central Madras. Surveys have revealed rates varying between 0·08 in dry Rajputana and 30 to 60 per mille in humid Upper Burma.

The explanation of these facts suggested by Rogers is that dry heat is inimical to the survival of the lepra bacillus outside the body but moist heat would favour this. Moreover numerous insects bites of hot humid climates produce minute lesions of the surface epithelium, which afford entrance to just those layers of the dermal tissues where the lepra bacillus flourishes best This conclusion was supported quite independently by the observation of Muir in 1923 (p 159) namely that the first discovered lesions in over one thousand leprosy cases many of which were probably the sites of primary infection were most numerous on the exposed extensor surfaces of the extremities. Thus both sets of facts support the now very generally accepted view that the organism most frequently enters the human system through the skin (p 85)

DISTRIBUTION AND EPIDEMIOLOGY OF LEPROSY IN VARIOUS COUNTRIES

Although at the present day there can no longer be any doubt that the bacillus of Hansen is the causative agent of leprosy yet we have still much to learn concerning the precise manner in which the organism passes from one patient to infect another person Consequently numerous recorded epidemiological facts have an important bearing on the probable mode of infection and on the prophylaxis of the disease. The best method of dealing with the vast literature bearing on these points was not easy to decide the plan adopted in this work is to relate the more important available data in the course of brief descriptions of the world distribution of the disease, which can subsequently be referred to when the various epidemiological factors are discussed

DISTRIBUTION IN EUROPE

We have already seen in the historical section that leprosy as an endemic disease died out of most of Western and Central Europe after its great prevalence in the Middle Ages, but continued to some extent in the more outlying parts such as Iceland Norway Sweden the Baltic Provinces and Black Sea areas of Russia, Cyprus Yugoslavia, Romania, Greece, Crete, Spain, and Portugal and a small area in the Maritime Alps The following data illustrate its present incidence in these countries.

Iceland.—Most interesting historical accounts of leprosy in Iceland have been published by Dr Ehlers, of Copenhagen and by Dr Bjarnhjedinssen, which may be conveniently summarized in the following chronological table —

A.D.
874—Iceland colonized from Norway
Twelfth and thirteenth centuries—Leprosy first known in Iceland, probably brought by Crusaders returned t Norway (Ehlers)
1415—Two-third of the population died of the black death
1555—Leprosy widespread and four leper houses decided on.
165 —Leper asylums opened but only one-tenth of the cases could be taken in.
1707—Small-pox killed 18,000 people (one-third of population) many lepers died.
1714—Total estimated at 100 to 120 or 3 to 3·5 per mille
1768—Leprosy increased again 280 or 6·0 per mille known.
1785—Leprosy reduced after a famine to 99, or 3 per mille.
1786—Ordinance passed forbidding marriage of lepers or families of lepers
800—200 lepers.
837—128 counted this is below the true number
1846—Measles epidemic carried off many lepers.
848—Danish Government, influenced by the non-contagionist views of Danielssen and Boeck closed the four leper hospitals. They were in bad condition with only 0 to 5 begging lepers and of little use.
872—43 lepers counted in 15 of 84 municipalities.
893—Proposal for leper asylums voted down.
894—Visit of Dr Ehlers, who saw 158 lepers and advised segregation measures.
896—226 lepers known, or 3·0 per mille.
897—Leper hospitals, built by Danish subscriptions, opened 81 admitted by end of year
1898—Segregation law passed in February
907—98 lepers, per mille a reduction of nearly two-thirds in ten years.
920—67 lepers, 0·78 per mille, a reduction of three-fourths in twenty three years.
932—25 lepers, or 0·26 per mille, reduction of 90 per cent in 36 years.
1 1932 Klemeyer reported that the number of cases had been reduced t 5 and that the benign anæsthetic form is now much more common than the more infectious nodular one, so the disease is well under control

The above is one long history of steady increase in the prevalence of leprosy checked from time to time by epidemics and famine, until in 1897 in place of a vacillating inadequate policy of leper asylums, effective segregation measures were taken followed by a rapid decrease in the disease.

Norway—The history of leprosy in Norway is of very special interest on account of the successful prophylactic measures which have been carried out there during the last 90 years, which will be dealt with more fully under that heading (p 100), The following data are mainly derived from Hansen's paper at the 1897 Berlin Leprosy Conference. The disease was present in the Middle Ages and a leper hospital was at work at Bergen in 1266

By the end of the sixteenth century it had decreased in the south and east and the leper hospitals were given up except a small one in the west. In 1645 St. George's Hospital was erected and between 1718 and 1753 the patients, mostly lepers increased from 58 to 135 In 1839 when Danielssen began his studies, there were 152 inmates at Bergen and 88 lepers in the Rekwas Hospital at Molde, erected in 1713 half way between Bergen and Trodjhem

In 1837 a Royal Commission proposed more asylums and in 1849 the large Lungegaarde Hospital was opened near Bergen under Dr Danielssen at whose instance a leper census enumerated 2079 cases in 1856 subsequently raised by further inquiries to 2833 or 1 91 per mille. In 1931 Lie reported only 68 cases remaining 0·023 per mille, mostly old uninfective nerve cases, and between 1925 and 1931 only 3 new cases had been found. The disease should therefore soon be stamped out of Norway after a prevalence according to Lie (1929) of 1000 years (*See* p 100 for details of the prophylactic methods used)

Sweden, according to Sederholm, had at least twenty leper hospitals in the Middle Ages a small focus has continued to the present day in the Helsingland and Dalecarlia districts. The disease is said to have been widespread in Bohusland on the south-west coast at the beginning of the nineteenth century and to have decreased rapidly after the great herring fishery came to an end in 1807 The hereditary theory of origin of Danielssen and Boeck prevented any measures against the disease being taken before 1856 and it was not until 1864 that a small leper asylum was opened at Jerfso Only after the discovery of the lepra bacillus by Hansen in 1871 was the contagiousness of the disease recognized In 1871 the attacked were noted to be either children relations, or servants of, or such persons who frequently visited, families residing in houses where the illness had been but married couples did not often infect each other In Helsingland 67 cases were reported in 1856 in 1861 86 were known and the highest number of 103 was reached in 1873 By the application of similar measures to those in Norway except that notification only was compulsory the number had fallen to 89 by 1907 and only 37 0 006 per mille, by 1923 19 of whom were segregated and 18 domiciled 24 of the total were over the age of 60 years (Jeanselme) In 1933 Kissmeyer reported 31 known cases, including 2 recent ones since 1928

Finland had a leper house as early as 1355 and in 1807 an asylum on a lake island In 1845 a leper hospital was built and

by 1872 the disease had greatly decreased, but was apparently reimported from Russia. In 1897 Saltzmann reported 67 cases 0·026 per mille. Admission is voluntary except in the case of those considered dangerous to others (Fagerlund) In 1931 Kusmeyer reported 34 cases, 26 of the patients being between the ages of 50 and 90 years he attributed the decline to the isolation of 27 mostly infective lepromatous cases.

The Baltic Provinces of Estonia, Lithuania, and Livonia (Latvia) contain an important focus of leprosy surviving from the Middle Ages from this the Memel district of Eastern Germany became infected about 1880 (p 66) Dehio reported over 1000 cases in the Baltic provinces in 1901 and 862 cases were then known in Livonia alone An interesting effort to control leprosy in this area was made by the Livonia Society for the Suppression of Leprosy founded by P Hellat by providing beds in leprosaria in 1898. By 1902 196 cases had been admitted but want of compulsory powers resulted in 84 beds remaining empty at the end of 1902 In Estonia greater success was obtained for since 1906 one-third of all the cases were in the official asylums and by 1913 seven-tenths were so cared for (Kupffer) More recent data show 17 cases with segregation of 15 of them, in Lithuania in 1927 and 249 known, with 210 segregated, in Livonia in 1922 (Jeanselme) In Estonia, Paldrock in 1928 reported 235 known cases 213 of these were segregated and 22 domiciled under medical care.

South Russia shows widespread leprosy in the Black Sea and Sea of Azov areas extending to the Caspian Sea and into Asia to the east of it up to the Aral Sea and to the south into the trans-Caucasian area. The figures recorded by Clemow varied between 0·02 and 0·05 per mille and totalled in 1895–7 1200 cases. Petersen at the Berlin Congress of 1897 estimated the lepers in the whole Russian Empire at 3000

According to Munch leprosy was probably introduced into the Crimea by a Genoese colony about the thirteenth century The disease spread from there into the Don Cossack, Cuban, Terek, and Astrakhan districts.

In 1927 Bortkewitsch estimated the lepers in the whole of Russia at 879, but Vladimirov gave the official number as 1500 in Soviet Russia and estimated them at 10 000 (Jeanselme) According to Sprawson in 1939 there were 3000 registered lepers in the Soviet Union Caucasus, 700 Turkestan, 1000 Astrakan 600 to 700 Far East, 100 and Yakutsk, 30

Greece and Crete.—According to Katsaina (1915) leprosy has for long been endemic in Greece it was probably brought by

In 1913 according to Stefanesco there were 553 known lepers in Romania Gehr in 1941 reported that 140 cases were known in Romania he estimated the total at 500 to 600 In Bulgaria only 7 cases were known

Italy.—According to Bordoni Uffreduzi Italy has a number of indigenous lepers for an inquiry after the 1897 Congress revealed 167 cases in twenty four provinces. In 1904 77 were known in Sicily 58 in Sardinia and a large, but unknown number in other provinces, in addition to returned immigrants from leprous South American tropical countries, especially Brazil.

At the end of 1925 274 known cases were distributed over 44 provinces. Range in 1930 placed the number at 391 0·01 per mille, spread over 47 provinces (Jeanselme)

An Old Indigenous Focus in the Maritime Alps of Italy and France is of great interest it involved the Liguria province of the former country and Provence in south-east France. Bolnet and Ehlers recorded that it is of very ancient origin, possibly introduced by the Phoenicians It was known in the seventh century in the sea-coast towns and in the thirteenth there were 26 leper houses in Provence. An inquiry in 1901 showed some 50 cases near Nice in the Maritime Provinces a considerable diminution since a previous search in 1893 the focus is not now considered to be a serious danger The decrease is attributed to improved hygiene the isolation of the well-to-do cases in their own houses and the rarity of marriages with leper families, who are avoided by the healthy The focus is maintained only by marriages between leper families and transmission of the disease to their servants—another striking example of house infection. In 1929 Jeanselme found only 11 cases in this focus, 10 being indigenous and 1 imported.

Spain is still widely infected with leprosy especially in the coastal districts of Galicia in the north west, Andalusia in the south and Valencia in the east 522 cases were known in 1904 and Tello estimated them at over 1000 In Galicia a higher proportion of females are affected owing to emigration of the husbands and the custom of promiscuous living of the women which favours spread of infection. Tello thought leprosy to be increasing in Spain where no measures were taken against it until a leper colony was established in the Alicante district of Valencia, in 1909 which contained 127 cases in 1915. Malaga Granada and Seville have leper hospitals and the Sanitary Colony of Fontilles was founded by a National Society Lepers are often expelled from towns and

the Phœnicians and increased after the Egyptian invasion in 1825 It is now rare on the mainland but common in the islands, especially in Crete, where Katsains estimated the number at 1000 in 1915 a number in agreement with the results of an investigation by Ehlers in 1897 The latter observer found the earlier segregation measures to have been illusory or even harmful, for many healthy persons were residing in the leper villages, including no less than 900 uninfected persons in the Candia one. Numerous infections were found among those living with lepers, several cases commonly being seen in one family or household. Ehlers therefore held that the anti-contagionists erred in quoting Crete as an example of the failure of efficient segregation measures. After the Greek occupation the island of Spina Longa was used as a leper colony but the conditions there do not appear to have been altogether satisfactory There is also a small leper colony in Greece supported by voluntary agencies In 1932 Copanaris reported that 549 cases or 0 08 per mille, were isolated. In 1941 Gehr estimated the total cases at 758 One third were in Crete, five-sevenths in other Greek islands, and the remaining 195 on the mainland

Cyprus was also infected with an estimated number of 228 cases in 1939 (Muir)

Yugoslavia.—In 1905 Glueck recorded that no less than 44 8 per cent of 317 lepers then known were nodular cases In 1926 Araujo reported that 75 cases were compulsorily isolated in two small asylums most of which came from Bosnia and Montenegro and that Recheljewitch estimated that the true numbers are at least 200 In 1941 Gehr reported 593 known cases in Jugoslavia, with 100 in Montenegro

Romania.—According to Babes report to the 1909 Congress, Romania showed two main foci of leprosy one on the Southern Carpathian Mountains and the other in the delta of the Danube. Compulsory notification was introduced in 1898 Recorded figures show 407 cases from 1897 to 1902 and 551 from 1903 to 1908 Here, again, the disease is a family infection with two to four lepers in one or two families in each place. An attempt at prophylaxis by means of obligatory isolation of cases in their own homes has proved a failure for between 1897 and 1903 245 such lepers isolated in their families gave rise to 83 new infections, and from 1903 to 1908 123 produced 61 new cases 63·9 per cent of the total infections were in relatives, 5 5 per cent in other persons living in the same house with lepers and the remaining 30 5 per cent in neighbours and persons living in the locality

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driven into mountains or remote places. A leper from the Philippines settled at Parcent in 1850 in an early stage of the disease it spread from him slowly through the neighbouring villages until, by 1887 60 cases had occurred and 20 communes were infected in Alicante province (Leloir) A census in 1914 recorded 898 cases spread over 33 provinces a number Sampelayo considered to be far below the truth. In 1932 Ortega gave the number of known cases as 883 In 1941 Gehr placed the known cases at 928 of these 486 were isolated The Health authorities estimated the total cases in Spain at 2000 to 2500 Algeria has been infected from Spain (Raynaud)

Portugal.—In 1898 Falcal reported 466 known cases in Portugal and estimated the number at 1000 in 1920 Gomes placed the number at 1553 In 1941 Gehr placed the known cases at 1124 234 of these were in the Coimbra district. A number of them occurred in persons who had returned from Brazil Vieira also stated that in a survey he discovered 3000 lepers

Malta.—Leprosy has been known here since 1687 It was found to be increasing in 1883 but it was not until 1895 that steps were taken to control it by means of compulsory segregation. In 1917 a Leprosy Commission recorded 220 cases in Malta and 29 in Gozo 112 cases 0 57 per mille, were isolated in the leper hospital. In 1926 Araujo reported 64 interned cases and 23 paroled after treatment, a total of 87 0·39 per mille. Isolation cost £100 per case per annum In 1938 Muir found 85 known cases

In **North-west Europe,** including Great Britain France, Belgium Holland Germany and Austria, the number of indigenous cases is so small as to be negligible. More numerous are patients returning to those countries after contracting the disease in tropical areas An inquiry in 1940 revealed only 40 cases in Great Britain, 17 of which were probably uninfective neural and tuberculoid cases all but 4 were either isolated in a home or under skilled care The danger of infection arising in the country is therefore extremely small. There are believed to be about 200 cases in the neighbourhood of Paris and a few at Marseilles. Only one case of leprosy is known to have occurred in men of the British Navy in the past 100 years this indicates that fleeting and chance contact with cases in foreign countries is not a frequent source of infection. Under the good hygienic and climatic conditions the imported cases very rarely give rise to new infections usually only as the result of such prolonged close contact as sleeping in the

same bed as an infective case McLeod has reported 3 such cases in England

* * * * *

It thus appears that there are considerable areas of Europe still showing endemic leprosy with a total of several thousand indigenous cases. With our present knowledge of prophylaxis and treatment it should be possible to stamp out this disease as has nearly been done by preventive measures alone during the last few decades in Norway and Iceland. In addition, a number of immigrants return to Europe yearly after contracting leprosy in the tropics, but with proper sanitary precautions they very rarely spread the disease

DISTRIBUTION IN AFRICA

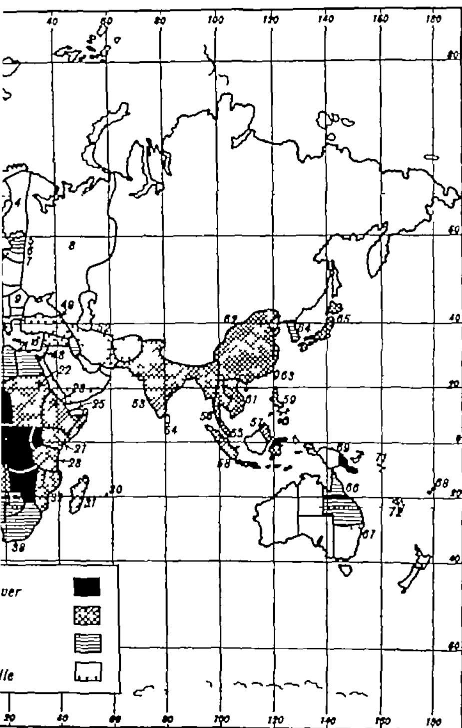
The great prevalence of leprosy in humid hot tropical Central Africa has already been pointed out (p 11) There are reasons for believing that the disease has spread with the opening up of the Dark Continent, for according to Mungo Park and Moore leprosy was introduced into West Africa by Sudan slaves Kermorgant stated that the disease increased with the spread of Mohammedanism owing to no precautions being taken against it. Tonkin during his travels found the disease very common from North Nigeria right across Central Africa to the Sudan. The figures in *Table I* show the rates per mille to be very high so this vast area of poor and undeveloped country presents the most serious leprosy problem in the world, with the possible exception of China.

North African Subtropical Zone with Low Rainfall.—It will be seen from *Map I* and from the data on pp 13–15 of *Table I* that this area, including from west to east, Morocco Algeria, Tunis, Tripoli and Egypt, shows the comparatively low estimated leprosy rate of under 1 per mille. This is in accordance with the low rainfalls of under 10 inches annually shown in *Map II* The dry French Mauritania to the south of Morocco is also reported to have very few cases. Tunis cases include a number of immigrants from Malta.

South African Subtropical Zone with Moderate Rainfall.—South Africa is extensively infected with leprosy with the highest rates in the western portion with the comparatively high rainfall of about 30 inches a year and high numbers in the neighbourhood of the capital and Cape Town. Wet Basutoland showed the highest rate of 2 per mille in 1937 The dry and sparsely populated Bechuanaland has the much lower rate of 0·25



Fig —Sketch map to show the distribution of



rates of incidence throughout the world. (See p. 10.)

The following historical data are of interest.

In *Cape Colony* leprosy was unknown until the middle of the eighteenth century when, according to Impey the disease spreading down from the north affected the Hottentots to a great extent and to a less degree the Bantu tribes, but it was not definitely known among the Bushmen or in the Basutos It was prevalent among the natives of the interior long before the arrival of the white man who did not therefore introduce the disease, although it was possibly augmented by free commerce with the infected West Indies. The first cases among the Dutch were found near Cape Town in 1756 the Government issued a warning and the affected families were so completely ostracized that the disease is said to have died out. As by 1817 leprosy was found to have increased considerably especially among the Hottentots, the lepers were all ordered to be segregated in a beautiful valley in the Caledon district at a considerable distance from Cape Town Over 400 were sent there up to 1845 when the plan was found inconvenient and some old military buildings on Robben Island at Cape Town were turned into a leper asylum which continued to 1931

Cape Colony which was earliest infected with leprosy still has the highest incidence in South Africa. Gregory's 1904 figures showed 2282 cases, 1 81 per mille and it is noteworthy that by far the highest rate is in the western province containing Cape Town with 4 04 per mille. In 1907 Mackay gave the number as 2790 2 21 per mille, for all Cape Colony

Spread to Griqualand West and Transkeian Territory.—In 1862 for political reasons leprosy infected Hottentots of West Griqualand west of the Orange Free State, were moved to East Griqualand to the south of the Drakensberg Mountains in the extreme north-east of Cape Colony They infected both the long track of country they passed through and their new headquarters at Kokstad, whence the disease spread widely until in 1895 there were about 80 in Kokstad district and 478 in the other districts The disease next spread to the *Basutos* who formerly kept themselves so aloof from other tribes that leprosy was rare among them and conf[illegible] to strangers up to 1870. In 18[illegible] er many Basutos to work in the Kimberley mines [illegible] contracted the and carried it to their homes, [illegible] atly increased the next twenty-five years and [illegible] on, 1 11 pe in 1895

The separ [illegible] for the di [illegible] f Impey L Mackay ar [illegible] ge Free [illegible] the Transv for Natal o [illegible] and 0·6 [illegible] dry and

populated (0·44 per square mile) Bechuanaland only 0·08 per mille—all considerably below that of Cape Colony itself It is of interest to note that in 1895 Impey reported that Pondoland although bordering on infected Basutoland was said to be free from leprosy owing to the chiefs excluding all lepers from the country on pain of death and that Zululand had very few cases on account of the drastic native customs regarding them There was however in 1939 a leprosy institution with 200 patients in Pondoland and another with 472 in Zululand

On the formation of the Union of South Africa 2226 cases were segregated in 1912 and 2501 in 1923 The 1938 annual report records 2 65 segregated cases in six institutions and 4502 patients who had been released as uninfective or recovered 1764 of whom were still under surveillance, making a total of 6767 0·69 per mille The effects of the isolation policy are dealt with on p 105

Tropical Africa with a Hot Humid Climate and High Rainfall.—As already mentioned this is the worst infected large leprous area in the world in proportion to its population. The following are the most important areas

Anglo-Egyptian Sudan —The northern and central dry areas have comparatively little leprosy Here Atkey found it especially infrequent among the Arabs living largely on goat's milk, but more frequent among the negro people without that advantage. On the other hand in the southern humid Bahr-el-Ghazal province a survey revealed widespread leprosy In 1932 Cruickshank recorded 6500 known cases of which 4800 were isolated and treated, including all the infective ones In 1935 there were 8461 known and 10,711 estimated cases, 1·84 per mille In 1940 Bloos reported that in the worst affected area of Li Rangu 958 cases were being treated in the settlement and 1458 at dispensaries the incidence was at the high rate of 40 per mille For prophylaxis *see* p 127

Abyssinia.—In 1930 Féran estimated the cases at 5500, 0 79 per mille, in this mountainous area with a heavy rainfall. This is doubtless an underestimate for in 1900 Wurtz and Leredde reported a leprosy rate of 20 per mille in the capital city of Addis Abbaba. In *Italian Eritrea* to the north-east of Abyssinia in 1932 the known cases were 555 or 1·39 per mille. The combined area of Eritrea and Abyssinia has an estimated rate of 1·01 per mille.

British Somaliland has a low rainfall and in 1938 Muir found 43 isolated cases and estimated the total at 200 0·58 per mille. Some had apparently come from Abyssinia

Uganda, to the south of the Sudan, is heavily infected, especially the western province bordering on the highly infected eastern Belgian Congo with possibly the highest rate for an extensive area in the world. In 1928 Cochrane estimated the Uganda cases at 20 000 5 4 per mille. In 1938 Muir found 1469 in settlements.

Kenya to the east of Uganda, with lower rainfall in the coastal portion was estimated by Muir to have 4000 cases 1 13 per mille, in 1938 Only 263 were isolated

Tanganyika also has a heavy rainfall and in 1928 Cochrane estimated the cases at 12 000 2 35 per mille of which 3147 were isolated in 1938 When under German control in 1912 they had isolated 3800 in 47 voluntary leper villages, but without treatment in the days before the improved methods were available.

In *Zanzibar Island*, off the coast of Tanganyika the cases were estimated by Cochrane in 1928 at 750 3 5 per mille. In 1938 Muir found 115 isolated. Compulsory isolation had been aban doned with improved morale.

In *Mauritius Island* the known lepers numbered 450 in 1928 and 40 were isolated. The estimated number is 2250 5 62 per mille.

Madagascar has a high incidence, with the heaviest rates on the eastern side where the rainfall is heaviest. In 1914 6373 cases were known, 2 per mille 4200 of them were isolated with the aid of the missionaries, thanks to the French Governor General Gallieni. In 1926 Abbatucci estimated the number at 6000 1 7 per mille, with 2306 isolated Infants born to lepers are cared for in special institutions for five years and if healthy they are then restored to healthy relatives—an important prophylactic measure which is dealt with later (*see* p 131)

Portuguese East Africa, or *Mozambique* was reported by Falcao in 1902 to be widely infected. In 1925 a Government survey registered 7000 cases in the southern Inhambane district alone 350 were isolated in a camp Cochrane in 1928 estimated the true number at not less than 14,000 4·67 per mille, so here also the problem is a serious one.

In *Nyasaland*, to the west of Mozambique, in 1935 219 of 319 known cases were isolated (Muir) The estimated number is 1600 1 per mille

Rhodesia.—Southern Rhodesia is heavily infected. In 1935 Moiser estimated the cases at 6500 5 36 per mille, with 1359 isolated. *Northern Rhodesia* also has a high incidence, which Cochrane in 1928 placed at 4500 cases, 4 5 per mille The whole of Rhodesia has a rate of 5 per mille.

Portuguese West Africa or *Angola* extends from the west of North Rhodesia to the west coast of Africa In 1904 Wellmann reported leprosy to be on the increase there and in 1928 Cochrane estimated the numbers at 12 000 3 per mille.

Belgian Congo is the largest and most central area of tropical Africa and presents a most serious leprosy problem The north eastern Nepoko region bordering on the highly infected western Uganda, is the most highly infected area In 1932 Dubois stated that the admitted incidence in the Congo as a whole is about 20 per mille making a total of 00 000 cases and van Campenhout reported in 1934 that surveys during seven years revealed 4600 cases among 443 700 people examined a little over 10 per mille. A commission in 1939 recorded that 60 363 leprosy cases had been found Of these 14 983 were isolated in colonies, nearly all of the agricultural type, and 3000 were in segregation villages or camps, all under treatment

French Tropical West African Possessions —In all these extensive areas leprosy is very prevalent as shown in *Table I* Nos 42 43 and 47 The main available data of the years mentioned from east to west in this region show rates per mille of 16 in French Equatorial Africa or French Congo according to Robineau 10 000 5 per mille in the Cameroons and 40 000 2 66 per mille, enumerated in French West Africa including French Guinea, Senegal the Ivory Coast and Dahomey Even these high rates are doubtless below the true figures, for the rate of 16 per mille for Equatorial Africa is calculated from the estimated numbers in a portion only of that area. Moreover in 1914 Blanquier found 348 cases among 5874 persons examined in three circles of the Ivory Coast, 60 per mille, Peyrot 33 5 per mille among 6000 examined in the Upper Senegal Niger area and Daniel estimated 40 per mille in the Middle Congo Very high rates have been met with in the Cameroons in 1902 Ziemann found 142 cases among 7000 persons coming for vaccination, 20 per mille, and another observer found one-fourth of the workers at Bangong to have leprosy Later Robineau reported 1500 cases in part of the Ebolowa circle, a rate of 130 per mille, and 4860 in the northern Garoua circle and he estimated the total in the Cameroons at 70 000 20 per mille.

British West African Colonies present an equally grave problem. E. Muir as the result of a tour in *Nigeria* in 1936 estimated the number of leprosy cases at 200 000 10·5 per mille. (*See also* p 127 on prophylaxis)

In the *Gold Coast* and *Togoland* area Dixey in 1931 reported 4000 known cases In 1936 E Muir reported that 400 cases were

isolated in this colony Surveys are required to ascertain the true numbers and incidence of the disease, which may provisionally be placed at 20 000 5 55 per mille

In *Sierra Leone* 3656 cases were known in 1936 and Muir estimated the true number at 18 000 10 per mille

* * * * *

It is clear from the above data that, while the incidence of leprosy is comparatively light in the dry subtropical northern area and in very dry South west Africa, the central tropical belt shows the heaviest and most extensively and severely affected tract of country in the world With the exception of South Nigeria the density of the population of tropical Africa is far less than that of leprosy-infected India and China so there is little doubt that the total number of cases is less in Africa than in Asia In South Africa the disease is also widespread although it has a lower incidence than in Central Africa and the conditions are far more favourable for the control of the disease in the politically more advanced and wealthy southern area, where much has now been done to deal with the scourge (p 105)

DISTRIBUTION IN ASIA

The **North Subtropical Zone** includes the low-rainfall areas of south-west Asia from Asia Minor to Afghanistan with low leprosy rates per mille. Thus *Turkey* is estimated to have 600 cases, 0·04 per mille *Palestine* 100 0·11 in *Iraq* the estimate is 300 0·12 and *Iran* has 105 isolated and 525 estimated cases 0 04 per mille. The numbers in Afghanistan also are believed to be few

The **Eastern Subtropical Zone** includes the high rainfall areas of Japan Korea and most of China with 30 to 60 inches annually Here the leprosy incidence is correspondingly higher with the estimated rates per mille of 2 in Japan, 0 95 in Korea and 2·25 in China the last is based on the very rough guess of 1 000 000 cases. Formosa in 1929 was reported to have 4000 1 per mille

In *Japan*, according to Ashmead, the ancient Ken system, under which when an infected person is found in a family of high social rank he becomes an outcast beggar and is precluded from marriage, may somewhat limit the spread of the disease. In 1932 Oltmans reported that 4638 of 14,261 recognized cases were isolated under the prevention law of 1907 but the Government was opposed to out patient clinics where early non-infective lepers might be treated in much larger numbers at a far less cost than the £20 per head per annum in leper hospitals exclusive of the heavy cost of the buildings. The care of leper children is also neglected there being

only 27 in all the Government hospitals In 1912 Papellier placed the cases at 102,583 1 94 per mille

China presents a still more formidable problem with a high but unknown incidence among an immense population For the evidence that the disease has been spread widely by emigrants from China, *see* p 8 The disease is most prevalent in the hot, humid southern provinces of Kwantung and Fukien and extends inland to Yunnan although rare in the desert Talifu area of that province. The disease also affects Shangtung where Maxwell has reported the high incidence of 1 per mille and that it is also common in Manchuria and Kansu, but rare in Chili so that all the more densely inhabited provinces are infected In Canton City Rai found an incidence of 1·6 per mille. The overcrowded boat population suffered most A few cases are being treated in missionary clinics and homes

The **Tropical Zone of Asia** once more shows the highest leprosy rates especially in the Dutch East Indies, Philippine Islands and French Indo-China

The *Philippine Islands* cases were estimated by Hasselmann in 1933 at over 40 000 2 71 per mille, in spite of the great effort made by the Americans since 1906 to stamp the disease out by compulsory segregation (*see* p 110) Surveys by Guinto and Rodriguez in Cebu Island show rates per mille varying from 0 45 to 19 7 Overcrowding in the more heavily infected areas only partially accounted for the wide variations. No relation between the distribution of the disease and the rainfall in the different islands was found by Rodriguez but as it is high in the whole area that is not surprising

The *Dutch East Indian Islands* as a whole were reported by Sitanala in 1926 to have an estimated number of 100,000 2 per mille of these 4303 were isolated The disease is said to be most prevalent among Chinese immigrants and to have greatly increased according to Broes van Dort, after the Dutch imported Chinese coolies. He also stated that leprosy is chiefly seen on the rainy west coast of *Sumatra* among the Chinese, among whom 1447 2 1 per mille, were traced by an incomplete enumeration in 1897 some of the indigenous tribes were infected In *Java* leprosy has been known since the seventeenth century and was reported to have increased after the closure of fourteen leper hospitals in 1868 as the result of a committee of the Royal College of Physicians of London having reported the disease to be hereditary and not contagious.

Among other recorded figures for this area are rates per mille of 10·7 in *Amboina Island* of the Moluccas group 5 to 10 per mille in

Madura 1 per mille in *Banda* where the disease is reported to have increased greatly after the closure of the leper asylum in 1872 *Sunda Celebes New Guinea*, and *Dutch Borneo* are all known to be infected *British North Borneo* was estimated by Cochrane in 1929 to have 500 cases, 1·9 per mille, only 50 of which were isolated.

French Indo-China—In 1927 Audibert estimated the cases at 30 000 1 5 per mille of these 5454 were isolated mainly in village settlements. He considered the disease to be a serious scourge against which further prophylactic measures were necessary especially the provision of attractive segregation villages, with land and treatment provided these were reported by Mathis to be popular Rigid compulsory measures were in force before the French occupation but fell into disuse. The French Colonial Government are now encouraging voluntary isolation with treatment.

Siam.—In 1929 Prince Vallabhakara estimated the cases at not less than 20 000 2 per mille with 480 isolated at Chiengmai in the north in a settlement first organized by Dr J W McKean and 180 in a Red Cross asylum near Bangkok. Over 1000 were attending the city clinic

Malaya.—In 1927 Green recorded that 818 cases were isolated at the rebuilt Kuala Lumpur Colony in the Malay States and 740 in two colonies in the Straits Settlements He estimated the total numbers at 1200 0 96 per mille. In 1933 the Senior Medical and Health Officer of Selangor Dr Smart, reported that just over 3000 lepers were undergoing institutional treatment. In 1937 there were 1520 patients in the institutions in the Straits Settlements 2120 in the F M S and 267 in Johore. Out patient treatment for voluntary cases has also been provided, since in 1929 the Principal Medical Officer F M.S approved the policy of attracting lepers to come early with treatment at special clinics without being arrested and confined as was formerly the case. Further children born to lepers are removed from their parents within fourteen days and no infection is known to have occurred among them.

Ceylon.—In 1930 Sivasethamporan reported that there were about 1000 known lepers in the island of Ceylon, and an estimated number of 3000 0·66 per mille By 1939 surveys had raised the known cases to 3648, 0·7 per mille. (*For* prophylaxis, *see* p 114.)

India presents an exceptional field for studying leprosy in a hot country owing to the six decades of census figures available and the epidemiological studies of Vandyke Carter in Kattiawar of Lewis and Cunningham in the Kamaon Hills, of the India Leprosy

Commission of 1891 and the recent studies of Muir and his colleagues. Although the census returns are deficient as regards the incidence in females and the number of early cases the figures have an important relative value as regards the distribution of the disease and the close relationship between high rates in wet and low ones in dry areas pointed out by the Indian Commission and later studied by Rogers (*see* p 12) *Table II* shows the number of cases and the rates per mille at each of the six decennial censuses for all India.

Table II—CASES AND RATE PER MILLE IN INDIA

All India				British India	
Year	*Population*	*Lepers*	*Rate per mille*	*Lepers*	*Rate per mille*
1872	198,281 169	108,807	0·54	101,590	0·55
1881	216,679,53	128,089	0·59	118,953	0·60
1891	274,373,929	126,244	0·50	1 0,509	0·56
1901	294 361,056	97 340	0·33	85,878	0·37
1911	315 56,396	109,094	0·35	92,453	0·38
1921	318,942,480	02,513	0·32	85,122	0·34
1931	352,837 778	147,9	0·42	126,867	0·47

The decline in the returns after 1881 is largely the result of excluding syphilis and leucoderma previously incorrectly included and to a reduction of leprosy following severe famines between 1891 and 1901 The disease is probably about stationary for the great increase in the cases enumerated in 1931 is certainly very largely due to the greatly increased interest taken in the disease after the discovery of an improved treatment. The Indian Commission found no relationship between leprosy rates and such factors as density or fluctuation of population, race, religion and caste, except that the poor suffer most and hill areas are more affected than the plains.

The Indian census figures only include the typical cases readily recognizable by the non medical tabulators For example, in 1875 C. Planck found 1665 cases in the highly infected Himalayan districts of Kamaon and Garhwal and in the plain district of Banda, all in the United Provinces, although the census of 1872 had only recorded 801 in those areas Vandyke Carter in 1876 discovered 472 cases in the Kattiawar State of the Bombay Presidency against 158 returned in the same census. The much more extensive recent surveys of Muir and his assistants revealed among a total of 2,435,610 persons examined in 4560 villages in various selected areas of India 16,499 cases of leprosy 0·7 per mille. In 61 districts

where the previous census figures were available the survey parties detected four-and-a-quarter times as many cases as had been returned, mainly early ones not recognizable by the non-medical enumerators. The committee appointed by the Central Advisory Board of Health in 1941 calculate that the total number of leprosy cases in India is probably about eight times the number reported in the 1931 census 150 000 This would make the number 1 200 000 They add It should, however be understood that at any one time only about one-quarter of these cases are infectious that possibly another quarter or less may become infectious and that many of them are exceedingly slight. The problem of dealing with such large numbers is thus proportionately diminished.

* * * * *

Asia thus shows very extensive distribution of leprosy with high incidence in the tropical areas with heavy rainfall from Bengal Burma and Siam eastward throughout Further India and Southern China, the Philippines and in the East Indian Islands. Owing to extensive immigration from the south of China the disease has been widely disseminated by Chinese in the East Indies, and, as we shall see below in the islands of Oceania.

DISTRIBUTION IN OCEANIA AND AUSTRALIA

Australia.—In the *Northern Territory* within the tropical zone, leprosy was found by C. Cook to be prevalent among the indigenous and immigrant native races and in 1926 he recorded that 6 cases had been reported among a white population of less than one thousand. In 1936 there were 117 cases interned.

Queensland, mainly within the tropical zone and with a comparatively high rainfall, has the largest number of lepers in Australia. In 1910 78 patients were segregated the cases had fallen to 50 in 1921 and numbered 63 in 1934. The true number may be placed at 315 0 32 per mille. Between 1924 and 1938 129 new cases were discovered in Queensland and 126 of them were isolated.

In *New South Wales* during the twenty six years from 1888 to 1913 the lazaret admitted 130 cases, 55 whites and 75 coloured persons, of whom 50 had died, 50 had been repatriated, discharged or had absconded. Only 21 0·014 per mille, remained at the end of 1913 In 1920 there were 20 cases with an annual admission rate of 3 all recent ones had been in coloured races. In 1936 16 cases were isolated at an annual cost of about £200 each.

Western Australia.—In the northern hot, humid Kimberley division 42 cases were found among 4001 persons examined, and

the total known numbers rose to 58 in 1936 Other areas show only scattered cases. In 1936 there were 85 cases interned

In *Victoria* only occasional cases are met with in Chinamen and in *South Australia* the disease only occurs occasionally in a sporadic manner *Tasmania* is reported to be free.

Thus Australia as a whole shows very little leprosy except in the tropical parts of Queensland and in the north west Coloured immigrants are chiefly affected and segregation and the repatriation of leper immigrants is being efficiently enforced In 1936 there were in all the leper stations 290 inmates including 43 Europeans

New Zealand was reported by Mason in 1903 to be free from any infection of the indigenous population among whom syphilis had been mistaken for leprosy by those who held a contrary opinion He found only one Chinese and four native lepers among immigrants.

British Oceanic Islands.—*Fiji* has long been infected there were 400 known cases in 1897 (Pernet) A Government leprosy station was established in 1900 and the present hospital at Makogai opened in 1911 In 1927 Neff reported 439 cases there. In 1936 Austin estimated the total number in Fiji at 2775 13·9 per mille. In 1941 the isolated cases numbered 702 including admissions from the Cook, Gilbert and other neighbouring islands, but in 1944 Austin reported that the number was reduced to 631 Formerly the natives are reported to have killed all lepers who developed breaches of the skin and they avow that since the British Government stopped the practice the disease has spread. The principal medical officer thought that leprosy had increased in recent years.

In the *British Solomon Islands* in 1938 Ross Innes found an incidence of 10·2 per mille in 21 615 inhabitants examined.

Nauru Island, which was taken over from the Germans after the 1914–18 War presents the latest and most striking example of the rapid spread of leprosy among a small community of about 2500 people, including 1000 Chinese. According to Dr G W Bray the first indigenous patient had lived near a leprous woman who came to Nauru from the Gilbert Islands in 1912 and by 1920 three more indigenous infections had occurred among contacts with the first one. In that year 30 per cent of the small population died during an influenza epidemic aggravated by a definite dietary deficiency Owing apparently to the resulting lowering of the resistance of the people, the disease spread with such appalling rapidity that when four years later in 1925 the whole population

was carefully examined, at the suggestion of Rogers, for early signs of the disease, no less than 30 per cent (300 per mille) of the native Nauruan population showed signs of the disease (Bray 1930) In 1925 the maximum number of 368 cases was reached, 189 of which were isolated as infective cases on one side of the island and 176 classed as uninfective were treated as out patients at a clinic. Fortunately 90 per cent of the cases were maculo-anæsthetic, and the remainder nodular and mixed cases (*see* p 137 *for the successful use of modern prophylactic measures*)

A few cases of leprosy have also been reported in recent years in the following islands Marshall Island, 6 cases Samoa, 8 cases Penrhyn Island, 9 cases, first introduced from Samoa, but partial segregation lessened the spread New Hebrides a few cases, brought from New Caledonia Friendly Islands, less prevalent than formerly Gilbert and Ellice Islands, a few nodular cases Wallis and Horn Islands, a few typical nodular cases and many patients with suspicious nerve signs Doubtless other small Oceanic islands have leprosy cases.

The Hawaii Isles, in the middle of the Pacific Ocean, suffered from a severe outbreak of leprosy since 1863 regarding which interesting information is on record. Attempts to stem the epidemic by segregation measures have given rise to much controversy (*see* p 108) The disease was not mentioned at the time the Board of Health was established in 1850 but in 1863 Dr Hillibrand reported leprosy to be spreading rapidly in Hawaii Island. He stated that it was introduced by the Chinese in 1848 the first local case being seen five years later and at the end of ten years it had spread considerably in the immediate neighbourhood of the first case. In 1864 it spread to the other islands of the group —a very similar history to that of the undoubted introduction of leprosy into New Caledonia and the Loyalty Isles by Chinamen.

As the majority of the cases were of the more highly infectious nodular form—as is nearly always the case during the *marked* increase of leprosy in any country—abundant sources of infection remained in the villages. The social conditions were most favour able to its spread as the people had no dread of the disease. They lived in one roomed houses, slept together under one coverlet, and indulged in promiscuous and almost unrestrained sexual inter course. It is also recorded that there has not been a single case of leprosy among the white or foreign population that was not connected with long and intimate association with those of the native race either having, or being predisposed to the disease Dr Mouritz in 1886 stated that inquiries into the histories of

cases always elicited that contact with a leper for long or short periods had existed He concluded The whole history of leprosy in the Hawaiian Islands, from its propagation to its present rapid spread and development, verily proves that it can only be accounted for by regarding it as a contagious disease. In view of the evidence given in a later section (p 82) that leprosy is essentially a house infection the very rapid spread of the disease under the favouring conditions above described is easy to understand.

The precise prevalence of the disease cannot be known on account of so many cases having been hidden by the natives until a late stage. The cases in the Molokai Settlement alone numbered from 8·67 to 11 88 per mille from 1870 up to 1894, after which a steady fall took place coincidently with more efficient segregation measures under American supervision to reach 2 3 per mille in 1915 (p 110) In 1925 Araujo found there were 1180 cases in Hawaii, 3 86 per mille, so seventy years of compulsory segregation laws often inefficiently administered in the earlier decades, had failed to solve the problem by eradicating the disease.

The French Oceanic Islands (New Caledonia and Loyalty Society (Tahiti) and Marquesas) This group of tropical islands has long been known to have some of the highest leprosy rates in the world, for the rates per mille shown in *Table I* of the first edition of this work were respectively 21 1 19 5 8·6 and 33·05 They are borne out by Jeanselme s figure of a total of 2020 known cases among 67 000 population, 30·1 per mille, in 1932

The introduction of leprosy into some of these islands by Chinese immigrants and its spread in an epidemic form have already been described (pp 8–9) Attempts at partial isolation under the control of the native chiefs has had little success (p 112) and although the height of these epidemics appears to be past the problem of eradicating the disease remains a serious one especially in the case of New Caledonia and the Loyalty Islands with a preponderance of the highly infective lepromatous type.

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The above data illustrate the serious nature of the outbursts of leprosy in Oceania during the latter part of the nineteenth century

DISTRIBUTION IN THE WESTERN HEMISPHERE

In the Temperate Zone.—*Canada* has had an interesting and long-standing focus of leprosy in the eastern province of *New Brunswick* which dates from 1815 in a poor French family from

St. Malo Most of the early cases occurred in the first affected family and their descendants dwelling in extremely unclean one roomed log huts (Liveing) A hospital built in 1844 admitted 32 cases during the next five years and in 1849 the present asylum was opened at Tricardia to which 150 cases had been admitted by 1882 (Jeanselme) in the absence of compulsory powers most of them were admitted in the later stages of the disease by which time they had infected others The number decreased from 36 in 1875 to 24 in 1885 remained at from 18 to 23 up to 1900 when Smith reported that segregation had become more prompt and by 1916 the number had fallen to 14, in spite of a few admissions from other parts of Canada and among immigrants from Iceland. A few cases have been detected among Chinese immigrants to *British Columbia* in Western Canada and in 1929 Page estimated the total known cases in the Dominion of Canada at 20 (p 67)

Greenland has also been found in recent years to have a few cases of leprosy

The northern one-third of the United States of America falls within the temperate zone, but as is shown below there is very little infection from imported cases in that area.

The North Subtropical Zone includes the southern two-thirds of the United States, Mexico and the Bermuda Islands.

United States of America.—*Table III* shows the relative incidence of leprosy in different groups of states in 1901 and 1927 The first column gives 276 cases traced in 21 states by the 1901 Commission. Of these 145 were born in the country 120 were foreign born immigrants, and the remainder doubtful 136

Table III.—Distribution of Cases in the United States in 1901 and 1927

Area	1901 Cases	Percentage	1927 Cases	Percentage
Southern States	187	61	120	82
Pacific States	26	9	7	5
Atlantic States	11	4	14	10
Central States	12	5	2	1
North-Central States	40	11	4	3
Total	276	—	147	—

had probably contracted the disease in the States, 68 outside and the rest were doubtful The 1927 figures are those of the 147 Americans at the Carville Federal Leprosarium in Louisiana State at the time of a visit by Araujo In addition, there were

64 foreigners, including 13 from China and 9 from Greece, making a total of 211 If suspected cases are added the total was 373 Estimating four additional cases for every known one Araujo puts the total for the United States at 1865 0·02 per mille

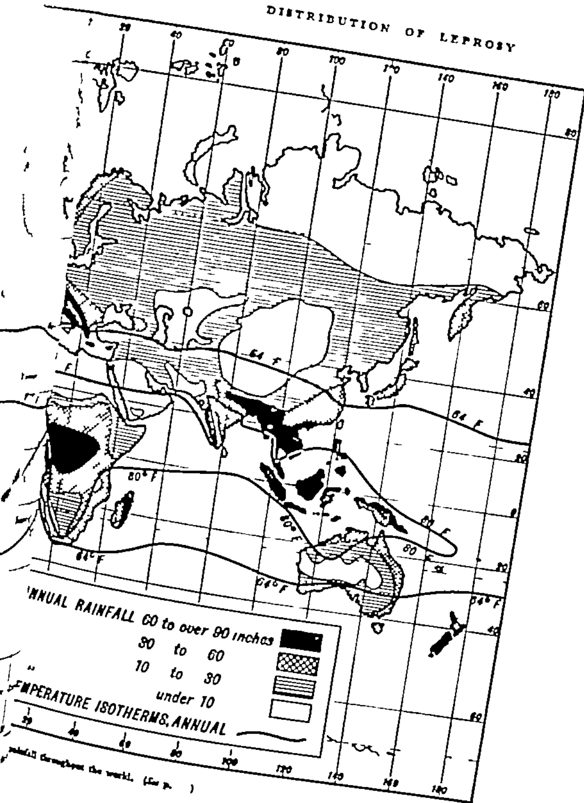
The data for the *Southern States* in *Table III* show the great preponderance of patients from this humid subtropical area even after allowing for the fact that the proximity of the leprosarium in the southern state of Louisiana would make their admission more likely In 1920 Boyd and Warren noted that most of the cases in this area were in whites of foreign parentage and that 60 per cent gave a definite history of previous contact with a leprosy case (*see* p 65 for spread of leprosy in Louisiana)

In the *Pacific Coast States* Hyde estimated that 158 cases had been found up to 1891 mainly among Chinese immigrants, most of whom had been repatriated In 1942 McCoy recorded that 475 leprosy cases had been found in California up to that date, of which 90 had died most of them had been immigrants from Mexico Pacific Islands and China Not more than 14 appear to have been infected within this dry area including two children of a leprous Japanese mother

The *Atlantic Coast States* show a few imported cases with very little tendency to spread McCoy states that in New York only 2 cases out of 40 might possibly have been infected locally

The *North Central States* formerly with many leprosy infected immigrants from Norway and Sweden, especially in Minnesota, are of special interest, because, so far from spreading in this healthy and socially advanced area the disease has nearly died out. As the result of a personal inquiry Hansen in 1888 reported that out of about 160 known immigrant leprosy patients in that region he could trace only 13 and perhaps 3 or 4 more were alive the rest had died without having given rise to any known cases. Later it was reported that 21 married leprosy patients had 78 children, all of whom remained healthy It is generally agreed that very few new cases originated from the leprous Scandinavian immigrants according to McCoy Close investigation of 40 imported cases showed only 7 contact cases and these in turn gave rise to only 1 doubtful case.

Hansen pointed out that Norwegian immigrant lepers to the northern central area of the U.S.A. lived in much bigger houses than they had been accustomed to in Norway and they generally had separate bedrooms in contrast to the overcrowded conditions that then obtained in Scandinavian countries. To these greatly



...rainfall throughout the world. (See p.)

improved social and hygienic conditions he attributed the remarkable tendency for the disease to die out from among those going to live in America. (See p 52 for Norwegian conditions.)

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The distribution of leprosy in the civilized countries of North America presents features of great interest. In the humid semi-tropical portion of the United States bordering on the Mexican Gulf the disease is definitely endemic (0·049 per mille in 1912) mainly among the European population among whom 76·9 per cent of the cases occurred (Hoffmann) Yet in the more northernly cooler and drier Pacific and Atlantic States very few new cases originated from the numerous imported ones. In the North-Central States, Minnesota, etc. the disease tended to die out from among infected immigrants under the better social and hygienic conditions in which they lived as compared with the countries of their origin, and extremely few new cases have arisen from them. In the *New Brunswick province of Eastern Canada* a focus remained stationary in its incidence for several decades as long as only voluntary isolation of late cases was carried out, but decreased under more active segregation. In *British Columbia* a very few new cases have originated from the Chinese leper immigrants. It is thus clear that, as in the highly civilized temperate zone areas of the Western Hemisphere there is little tendency for leprosy to spread under favourable social conditions, although it may do so to a moderate extent in subtropical ones such as Louisiana, but to nothing like the degree met with in backward tropical countries

Mexico, the northern part of which lies in the subtropical zone, according to the Health Report of 1929 had 1450 known cases, 0·09 per mille. In 1902 Espada recorded that the drier subtropical areas suffered less than the humid tropical Yucatan district with the high rate of 1 93 per mille. In 1936 Uruefla reported 3882 known cases 0 24 per mille

The **Bermuda Islands** also lie in the subtropical zone and in 1898 12 cases 0·7 per mille, were recorded there.

INCIDENCE IN THE TROPICAL ZONE OF AMERICA

The West Indian Islands.—We have already seen (p 7) that this area was mainly infected through the African slave trade and leprosy is still very prevalent in it.

In *Cuba* in the year 1935 Setién recorded that 387 were segregated in the Rincón leprosarium no less than 278 of these

were nodular ones showing a severe and highly infectious type to be present. The total may be estimated at 2000 0 57 per mille.

In *Haiti* Klingmuller in 1928 recorded 200 known cases and an estimated rate of 0·43 per mille

In *Porto Rico* de Borao in 1928 recorded 137 known and 60 segregated cases he estimated the total number at 400 0 31 per mille. In 1940 the recorded cases numbered 102 at least as many more are believed to exist (Doull)

In the French islands of *Guadaloupe* and *Martinique* Jeanselme in 1928 reported 850 known cases, 1 9 per mille.

In the *Virgin Islands* in 1930 a survey revealed 127 leprosy cases, together with 20 suspected cases. The definite cases gave a rate of 5 1 per mille. There has been a rapid decline during the past 30 years more especially this is attributed to improved social and economic conditions and the isolation of cases, commenced in 1888 and made fairly complete since 1910

In the *Dutch West Indies* Broes van Dort in 1896 reported 17 cases 2·9 per mille In 1932 Lampe reported 1107 known cases 6·75 per mille.

The *Leeward Islands* medical reports for 1937 showed the following incidence of leprosy *Antigua* had 34 segregated and 35 free a total of 69 (in 1944 the known cases numbered 90) *St. Kitts and Nevis* 41 segregated and 22 free, a total of 63 (in 1944 the known cases numbered 90) and *Dominica* reported 32 cases The total of known cases therefore was 164 or 1 17 per mille. Cochrane, as the result of a visit to the West Indies for the British Empire Leprosy Relief Association concluded that the true numbers must be considerably higher in the absence of surveys and that new infections among children indicated that the disease is spreading aided by the poor economic conditions in the islands.

The *Windward Islands* reports for 1937 showed the segregated numbers to be 14 in *Grenada*, 25 in *St Lucia*, and 17 in *St. Vincent* a total of 56 or 0·32 per mille No free cases are recorded and here again the true figure must be much higher probably two or three times the known cases, although the rate is lower than in the Leeward Islands and with fewer advanced contagious nodular cases, as Cochrane pointed out in 1935

The *Bahama Islands* reported only 4 leprosy hospital admissions in 1935 *British Honduras* reported 1 hospital admission in 1936 The *Bermuda Islands* in 1932 recorded 10 cases in the leprosy hospital, 0·23 per mille.

Jamaica is by far the largest of these islands In 1942 Muir

found 172 cases were compulsorily isolated they included 105 lepromatous and mixed cases, 38 neural, and 29 with the disease arrested. The last group might be discharged. The rate per mille of those known cases was 0·15, probably only one fifth of the true number The data of the six decades worked out from the annual medical reports by Rogers show a great reduction from the 450 cases and 0·73 per mille rate of 1891 with compulsory segregation since 1896 but much of the reduction is due to the repatriation of Indian cases

Trinidad is the next largest and most southerly of the group and in 1936 the segregated cases numbered 399, 0 89 per mille, against 149, 0 97 per mille, in 1881 and 526 1 5 in 1921 Compulsory segregation was only commenced here in 1915 and a greatly improved island settlement was provided some ten years later with apparently beneficial results. In 1942 as the result of a partial survey Muir estimated the true number of cases at about 1000 2 2 per mille. Compulsory isolation is in force and there are 7 or 8 clinics for early amenable and uninfective cases. Among the children of 178 schools 83 new and mostly early cases were found

Barbados—From 1901 to 1941 there were 471 cases admitted to the lazarette, more than half from the parish of St. Michael where the principal town is situated In the latter year there were 56 inmates most of whom form a residue of hopeless cases It is held by many medical practitioners that there is a considerable number of open cases in the island, but the lazarette is not attractive, and, according to the law only those begging plying certain trades, and using public buildings, can be compulsorily segregated. The Government have approved a scheme for making a thorough survey

The Central American States are also infected but little is known regarding the incidence of the disease except in *Panama*. There the Palo Seco leper asylum is noteworthy for marriages of the lepers being allowed only after sterilization of the male on his written request an effective plan of preventing children of marriages becoming infected later by their parents which is deserving of wide imitation. Hurwitz in 1936 reported 108 segregated cases 4 3 per mille

South America

The history of the infection of tropical South America by the Portuguese and Spanish armies and immigrants and later through the African slave trade has already been recorded (p 6)

British Guiana.—Neal stated that over 400 cases in negro slaves are recorded in old documents and that only those aboriginal Indians who associated with cases of leprosy in the asylum became infected. Before the abolition of the slave trade the Dutch planters isolated all discovered lepers, with the subsequent removal of *these restrictions the disease spread. Later still East Indian* and Chinese immigrants brought leprosy which still exists among them. The asylum at Mahaica received 77 cases in 1858 and by 1878 a total of 11 0 has been admitted. They included 6,7 Negroes, 339 East Indians, 87 Chinese, and 35 Europeans, 32 of whom were Portuguese. In 1904 Hillis recorded a rate per mille of 4, mostly anæsthetic cases. In 1928, 67 cases were segregated at Mahaica. Soon after modern methods were adopted as described under prophylaxis (p. 116) with the result that the known numbers rose by 1936 to 794, including 374 isolated in the settlement, most of them being voluntary admissions, the remainder were treated at out-patient dispensaries. In 1942 Muir put the total number at 1000, about 400 of whom were at Mahaica.

Dutch Guiana or Surinam.—The origin and spread of the disease was the same as in the adjacent British and French territories. *In 1728 the leprosy patients were forbidden to use the* roads, in 1763 their importation was prohibited and by 1790 the white races had become infected and the first asylum was founded. Many of the slaves emancipated in 1863 were affected and by 1897 Broes van Dort estimated the total at 2000, no less than 25 per mille. The various repressive laws were unenforced but the Christian community supported two leper asylums. In 1932 Lampe reported 1107 known cases, 6.75 per mille, 482 of whom were isolated. *Efforts have been made to* introduce modern methods of control.

French Guiana is believed to have been infected with leprosy through imported African slaves in the second half of the seventeenth century and an edict to exclude leprous slaves was passed in 1685 but not enforced. Various ineffective attempts to isolate the lepers also failed. In 1859 Dr. Laure stated that the disease had increased so much that one-tenth of the population, 100 per mille, were affected, but elephantiasis arabum was probably included. In 1898 only 67 of 450 known lepers were isolated and no sufficient precautions were taken, surprising promiscuity being allowed. In 1900 Clarac found the disease to be increasing, about 11 per mille being infected, especially the European convicts, over 90 per mille of whom were reported infected in 1918 (Leger), when the total number of cases was estimated at 573, or 22 per

Subsequently the unremitting labour of Dr H C de Souza Araujo has revealed a higher incidence in Brazil in 1936 he recorded that 30 750 cases had been enumerated and he estimated the total number in Brazil at 48,440 1 1 per mille. Of these 11 835 were already isolated in fifteen sanatoria under very favour able conditions, so much is now being done towards reducing the disease.

The **Southern Subtropical Zone** includes nearly the whole of Chile Paraguay and Argentina as well as Uruguay

Chile with a very dry mountainous climate is practically free from leprosy

Paraguay, between Brazil and Argentina has a considerable rainfall and Lindsay thinks the disease has increased greatly there in recent years Browning in 1035 estimated the number at 4000 to 10 000 the lower figure gives a rate of 4 44 per mille.

In **Uruguay** a little farther south according to Guerrero the number of known cases increased from 47 in 1898 to 237 in 1929 and Vignale also thinks there has been a large increase, mostly near the coast (Jeanselme) In 1935 Browning estimated the total cases at 500 0·33 per mille, 40 of which were segregated.

The subtropical area of South America shows a much lower incidence of leprosy than the more humid and hot tropical countries already dealt with

Argentina was infected by the Spaniards at the time of its conquest and hospital records show 309 lepers in nearly 100 years from 1798 to 1896 The average yearly admissions have gradu ally risen in the last thirty years from 1 to 14 with increasing commerce most of the reported cases have been in foreigners. The most affected provinces are all in the north and east of the country extending up from Buenos Aires to Corrientes on the Brazil border A leprosy conference in 1906 reported a total of 730 0·13 per mille (B Sommer) which is admitted to be an under estimate In the same year a stringent law was passed but up to 1917 urgent requests for leper asylums had met with no response (Penna)

Several observers have reported an increase in the prevalence of leprosy In 1927 Aberasury held that there were 2870 in the State of Buenos Aires alone (Jeanselme) In 1923 Garcia put the num ber at 6568 known cases, 0·75 per mille, 5444 of which were segregated but Jeanselme (1934) stated that actually 7500 are segregated and an equal number are at large, making a total of

15,000 1 5 per mille so the problem is a serious one. Susim in 1935 placed the known cases at 2989 and estimated the total at 7500 0·62 per mille.

* * * * *

The records are unanimous in indicating that the aboriginal American Indians were free from leprosy until the Spanish and Portuguese conquerors and colonists brought the disease with them, which shortly after was greatly extended by the enormous number of Negro slaves imported from the great tropical African leprous centre, and, after the emancipation of the slaves, supplemented by Chinese and East Indian immigrant labourers The highest incidence of leprosy has occurred in the wet tropical countries of the northern portion of South America, with the most intense focus in Guiana some of the West Indian islands also show high rates Numerous attempts at prophylaxis made during the last two centuries have been characterized by feebleness and vacillation in execution which have rendered them, with few exceptions, of little or no use until recently (p 98) With our present knowledge it should prove possible greatly to reduce leprosy especially in the smaller island colonies

Table IV—ESTIMATED LEPROSY INCIDENCE IN THE BRITISH EMPIRE

AFRICA	
Anglo-Egyptian Sudan	11,000
Uganda	20,000
Kenya	4,000
Tanganyika	12,000
Zanzibar	750
Mauritius	2,250
Nyasaland	1,600
North Rhodesia	6,700
South Rhodesia	6,500
Basutoland	1,000
South African Union	9,000
Nigeria	400,000
Gold Coast	20,000
Sierra Leone	18,000
TOTAL	512 800

ASIA	
India and Burma	1 200,000
Ceylon	3,600
Federated Malay States	3,000
Straits Settlements	3,000
British North Borneo	500
TOTAL	1,210,100

OCEANIA	
New Guinea	2,500
Nauru Island	159
Solomon Islands	900
Fiji	2 775
Australia	400
TOTAL	6,734

AMERICA	
West Indies	2,000
British Guiana	1,000
TOTAL	3,000
Sundry	848

GRAND TOTAL	1 733,482

The total of 1 733,482 must still be below the correct figure which may provisionally be placed at 2 million cases in the British Empire. Experience in India and elsewhere shows that when the early cases are included not more that about one of every five is seriously infective. This reduces the difficulty of dealing with the problem to manageable proportions with the aid of the modern methods of prophylaxis described in Section III

Many guesses have been made regarding the total leprosy cases in the world The available data in *Table I* amount to about 3 091 000 This is probably an underestimate and five million is as near as we can at present get to the true figure

Section II—EPIDEMIOLOGY AND COMMUNICABILITY

CHAPTER III

CONDITIONS INFLUENCING THE PREVALENCE OF LEPROSY

In describing the incidence of leprosy in different countries, various factors influencing the prevalence of the disease have been recorded, which it is advisable to summarize before proceeding to discuss its aetiology

FAVOURABLE CONDITIONS

Low Stage of Civilization and Hygiene.—A low stage of civilization, with the accompanying grave hygienic deficiencies, is the most important factor influencing the prevalence of leprosy This is evidenced by the extensive infection of Europe during the Middle Ages and by the disappearance of leprosy as an indigenous disease from most of Europe with the steadily improving conditions under which the people lived Moreover in the tropical and subtropical countries in which leprosy is now most prevalent, such as in Africa, India, Southern China, Malaya and Oceania, the conditions under which the numerous very poor inhabitants live are but little removed from those obtaining in Europe during the height of the leprosy prevalence in the eleventh to the fifteenth centuries.

On the other hand, leprosy is no longer indigenous to any material degree in the more hygienic Western European countries. Moreover in the northern temperate areas of the United States among a number of infected Norwegian immigrants the disease almost completely died out under the improved hygienic conditions in which they lived According to Hansen this was mainly due to the more spacious houses they occupied allowing each person to have his own bedroom, an advantage that they had not enjoyed in Norway Again in England, France and other advanced countries of western Europe several hundred persons have returned from the tropics suffering from leprosy contracted there during the last few decades, but, except in rare instances,

they do not infect those among whom they live. So it is clear that there is little or no tendency for leprosy to spread under favourable hygienic conditions in temperate climates although, as we have seen (p 42) the disease has become indigenous to some extent among well-to-do French families in the subtropical areas of the southern parts of the United States of America especially in Louisiana with a hot, moist climate favourable to its spread (p 11)

Defective and Overcrowded Houses furnish most favourable conditions for the spread of leprosy and it is noteworthy that in the main endemic tropical areas above mentioned the great majority of the poor inhabitants live in overcrowded one roomed houses. Thus, in Hawaii Green pointed out that the small one-roomed houses crowded with men women and children were very favourable to the spread of leprosy and in Nyasaland Hearsay regarded *the overcrowding induced by the hut tax as favourable to both* leprosy and tubercle. Rodriguez in 1931 in the Philippines reported a close and mathematically demonstrated relationship between density of population and leprosy prevalence in Cebu, and he agrees that overcrowding especially as regards sleeping accommodation, predisposes to infection.

Promiscuity, General and Sexual, so greatly favoured by whole families living in overcrowded one roomed huts, has been repeatedly shown to be a most important factor in the spread of leprosy especially among the poorer tropical races such as in the Hawaii and Oceanic Island epidemics of the last hundred years This is clearly brought out in the Hawaii reports (p 36) including the frequent infection of Europeans through irregular sexual relationships with the native women (p 81) Hillis recorded the same influence in British Guiana and an increase of leprosy in Jamaica at this period was attributed to free sexual intercourse among leprous persons Newman also noted the influence of the unrestrained sexual relationships in England in the Middle Ages as favouring the increase of leprosy In the Galicia province of Spain the exceptionally high incidence of leprosy among females was attributed by Tello to their habit of living promiscuously while their husbands had emigrated and in the Marquesas Islands epidemic leprosy was favoured by horrible promiscuity (Buisson) Infection is predisposed to in India by the Hindu joint family system under which several generations live together in one large house nine infections having been found in one such instance. I Santra in 1929 recorded that Bengal surveys showed that villages with a single caste were least affected, but

villages in which all castes mix together freely have the largest number of cases.

Favouring Social Customs.—Great sociability of certain races has been shown to favour the spread of leprosy in various parts of the world. Thus Hansen records that during the frequent social visits in Norway it was considered very bad form for a visitor to object to sleep in the same bed as a leper if not in a very advanced stage of the disease. In the Sandwich Islands, in addition to the great sociability of the people, their customs of smoking the same pipe and eating out of the same dish the latter habit being very common among the poor of most tropical climates, favour infection. Moiser mentions that beer-drinking feasts in which all drink from the same vessels in common cause the spread of infection in S Rhodesia

Absence of Fear of Lepers has been found in various parts of the world to favour the spread of leprosy especially among the Mohammedans in North Nigeria, Senegal, French Guinea (Kermorgant) in French Equatorial Africa, in the Dutch East Indies in Hawaii and the Oceanic Islands. In Europe the same factor has been noted by Hansen in Norway and by Munch in South Russia among the peasants on the left bank of the Volga; although among the people on the right bank under military Cossack government, who isolated leprosy cases, the disease had almost disappeared.

Spread by Migration of an Infected Tribe has been recorded in South Africa (p 26) Maxwell in 1931 reported a tenfold increase within a few years in the leprosy cases seen at the Mukden Mission Medical College thus followed the immigration into Manchuria within three years of some three million people from infected provinces of China.

Closing of Leper Hospitals and Cessation of Segregation Measures, as a result of the Royal College of Physicians report of 1865 declaring leprosy to be non-infective but hereditary were recorded to have been followed by an increase in the prevalence of leprosy by Hillis in British Guiana with most disastrous consequences by Munro in St. Kitts, by Broes van Dort in the Molucca and Oeliasar Islands, in Java, by Drognant Landré in Dutch Guiana and by Ehlers in Iceland the last instance was the result of the heredity theory of origin of leprosy of Danielssen and Boeck.

Deficient Diet has been thought by many to predispose to leprosy The great prevalence during the Middle Ages has been attributed by some to the deficiency of fresh animal and vegetable

food, especially during the winter months, when large quantities of salt fish were consumed (Munro and Newman) the latter we now know to be very defective in vitamins so essential to the maintenance of the resisting powers of the body to microbial invasions. Tonkin has suggested that the nearly total absence of animal proteins from the food of the highly infected tribes of Nigeria and the Sudan may be an important factor in the grave prevalence of leprosy in that extensive tropical area. Atkey in 1934 reported the infrequency of leprosy in the Anglo-Egyptian Sudan among Arabs, who live largely on milk, as compared with the greater incidence among negroes without that advantage. Keil in 1933 recalled that in Dutch Surinam the relationship between a poor diet of rice and salted meat and fish has long been held to predispose to leprosy infection. Burnet in his report to the League of Nations in 1931 also stressed the importance of a diet rich in vitamins, in addition to the modern chaulmoogra oil treatment. Muir in 1927 pointed out that leprosy incidence is high in Burma and China, where there is deficiency of milk but in Calcutta Chinese patients do very well under the modern treatment combined with a diet including milk, whole wheat bread, and fresh vegetables. The harmful effect of eating rotten fish is dealt with on p 61 and that of a diet deficient in vitamins in Nauru Island has already been mentioned (p 35)

The Habit of Going Barefooted has been found to predispose to the prevalence of the anæsthetic form of leprosy in a number of countries (p 89)

UNFAVOURABLE CONDITIONS

Conditions unfavourable to the spread of leprosy are mainly the opposites of the above-described circumstances.

Highly Civilized Conditions with Good Hygiene, as already pointed out.

Adequate Housing with separate sleeping rooms for each adult member of the family other than married couples leading to less promiscuity especially sexual, and absence of such favouring customs as a family smoking the same pipe and eating out of the same dish

The Fear of Leprosy leads to active measures to prevent contact by means of ostracism of the infected families in civilized races. This led to the disappearance of leprosy for a considerable time in South Africa after the 1756 outbreak according to Impey and in Louisiana in that of 1785 according to White Among some savage tribes more severe measures, such as forcible

isolation of lepers at some distance from the villages, their food being taken out to them, are practised by the natives of Senegal, the Ivory Coast, the Comoro Islands and in Madagascar according to Kermorgant. In the last mentioned country the disease was reported to have increased after the abolition of this preventive measure on the French taking possession of the island. Dalziel reports the same practice among the Hausas of Sokoto and Heckenroth in the Niger region. Rogers was informed during a visit to the Garo Hills in Assam that the same custom of isolation was practised there, with the addition that if the patient lived too long he was made comatose with drink and cremated alive in his hut. In the Kattiawar State of Bombay Vandyke Carter long ago reported the drowning of lepers. Isolation, together with burning the patient's bed and deep burial after death, are practised in Indo-China. In Laos there are few lepers on account of former rigorous isolation by the inhabitants in China isolation of advanced lepers is special villages has long been used to a considerable extent. Even in Spain lepers are reported frequently to be expelled from towns and driven into mountains and desert places. Although there is good reason for believing that these measures do something towards limiting the spread of leprosy they often fail to stamp out or greatly to reduce the disease on account of the incompleteness and inefficiency of the measures themselves and the fact that most of the cases are isolated only when they have reached an advanced stage and have already infected others of their household

More severe and cruel methods have been adopted by some savage races with greater success such as killing all young lepers by the Zorubas of Nigeria (Dalziel) and the destruction of all lepers as soon as they develop ulcers in Nyasaland (Hearsay) and in Fiji only a few decades ago Chinese officers have been known to shoot lepers and bury them in trenches into which quicklime has been placed. The exclusion on pain of death of all lepers from Pondoland in South Africa and native customs in Zululand have resulted in few lepers being met with (Impey) In Sumatra the Dutch Government have had to protect the indigenous lepers from being burnt alive by the natives. These highly effective measures are inapplicable among civilized races, although their partial success is not without its lessons.

The Escape of Tribes having little or no intercourse with leprosy affected races has already been shown to have been an important factor in protecting the former from infection with leprosy among the aboriginal Indians of British and Dutch Guiana (pp 6 46) and Colombia (p 7) Hall has reported (*Journal of*

the Leprosy Investigation Committee) that among leprosy infected negro slave families exiled deep into the North Brazil forests the disease was found many years later to have died out from among them under the isolated and more open-air life of their new conditions

Epidemic Diseases attended by very high general mortality have on several occasions resulted in great, but usually only temporary decrease in the prevalence of leprosy as in the instances already mentioned regarding Iceland (p 17) and the black death in England in the Middle Ages (p 6) As late as 1919 Atar reported that in the Garupa province of Brazil leprosy rapidly diminished from 1893 when malaria became and remained common

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All the above evidence points to leprosy being a communicable disease, the spread of which is favoured by insanitary conditions especially in a hot, humid climate. Infection is aided by defective and overcrowded houses, general and sexual promiscuity social customs connected with sleeping eating and smoking together and the absence of all fear of lepers which leads to the neglect of precautions against close contact with infected persons, and the absence or abandonment of all prophylactic measures against the disease. It is aided by an ill-balanced diet or one deficient in fresh vitamin-containing elements The contrary conditions are unfavourable to the prevalence of leprosy

CHAPTER IV

THEORIES OF THE CAUSATION OF LEPROSY

WHEN we consider that during the long period which has elapsed since Hansen discovered the bacillus of leprosy in 1871 an immense amount of research work has been done all over the world without having yet fully elucidated the manner in which the organism passes from the diseased to infect the healthy it is no matter for surprise that during the centuries leprosy has been known various theories have been put forward to account for the incidence of the disease. At the same time many facts have been brought forward which are worthy of consideration in the following brief historical account of the theories of pre bacteriological days.

ANCIENT BELIEFS IN THE INFECTIOUSNESS OF LEPROSY

The nearly universal ancient belief in the infectiousness of leprosy is so well known as not to require detailed consideration It is illustrated by the severe measures taken against the spread of the disease both in Biblical times and during its prevalence in Europe in the Middle Ages already described (p 3) and those adopted by various savage races as dealt with in the previous chapter (p 54) It is not surprising that exaggerated opinions regarding the contagiousness of leprosy have been so long held in view of the terrible deformities of face and extremities brought about by it and the slow and insidious spread of the disease. Nor is unreasoning dread of leprosy by any means extinct even in the most educated races of the world. For example, on a leper being brought into court in the United States of America most of those present, including the judical ermine fled from the room. Again the people of an English country village agitated against the presence of a leprosy patient in a nursing home with ample private grounds and under perfect sanitation, although it is well established that leprosy does not spread in temperate climates under favourable hygienic conditions (p 50)

THE HEREDITY THEORY

Still more remarkable was the ascendancy gained in Europe during the nineteenth century by the theory of the almost exclusive origin of leprosy through heredity due very largely to the teaching of the Norwegian authorities, Danielssen and Boeck, in their book published in 1848. In certain countries the hereditary factor in addition to contagion, has also been believed in for centuries, especially in China and Japan and in some parts of Africa such as North Nigeria (Dalziel) It is very significant that in such countries it is admitted that the alleged hereditary taint does not usually make its appearance until the age of puberty and the disease is never congenital, so the facts can be explained at least equally well by family infection In China the hereditary influence is believed not to extend beyond the fourth generation up to which the descendants of lepers are not permitted to marry into families free from the disease, and they may marry only with descendants of leprosy infected families of the same degree of remoteness from the leper ancestor as themselves

It is of interest to note the nature of the evidence of Danielssen and Boeck, which served to convince their contemporaries of the middle of the nineteenth century before our present knowledge of the laws of heredity was available They regarded the occurrence of two cases of leprosy in a family within four generations *as evidence of hereditary origin* quite irrespective of whether the later patient was in the direct or in a collateral line of descent or was born before or after the infection of the ancestor from whom he was considered to have inherited the disease and irrespective of whether the parent was attacked before or after his offspring—all being regarded as evidence of heredity They recorded the following figures on that basis (*Table V*)

Table V—EVIDENCE OF HEREDITY IN LEPROSY

	Generation				Total Cases	Per Cent	Paternal	Maternal
	1st	2nd	3rd	4th				
Direct descent	20	40		8	69	32·4	29	40
Collateral descent	38	58	7	13	116	54·5	52	64
Spontaneous origin	—	—	—	—	28	10·1	—	—

As Landré pointed out as early as 1869 according to the above table, the alleged hereditary influence showed itself more strongly in the collateral than in the direct line and in the more more distant second and fourth generations than in the more

closely related first and third generations, quite contrary to the laws of inheritance. Further if the cases of collateral descent are omitted as affording no evidence of hereditary influence, as both Landré and Munro maintain should be done, then 70 per cent of Danielssen's tubercular and 62 per cent of his anæsthetic cases become of spontaneous origin instead of the 10·1 per cent in his table, and the few cases in the first direct generation indicate very feeble hereditary influence, even when the possibilities of family infection are put on one side At St. Kitts Munro found among 64 cases with reliable family records there was no family history leprosy in 34 and of the remaining 30 there was a history of direct descent in only 9—data much against hereditary origin.

Hansen recorded having found only 51 of 210 lepers, under one fourth, had leper relatives in the direct line of ascent in spite of frequent intermarriages in small isolated communities. He pointed out that even in Norway it is perhaps remarkable that where the appearance of leprosy may be considered as of relatively recent date, there is very seldom any relationship between the lepers, nor do the latter descend from leper families of other places Holmsen has recorded very instructive Norwegian figures regarding 93 lepers, only 12 or 13 per cent, of whom had parents or grandparents who suffered from the disease, and no less than 11 of the 12 parents or grandparents were attacked after the birth of their children, so that in only 1 of the 93 was any evidence suggesting heredity found

Vandyke Carter in his report on a careful investigation of leprosy in the Kattiawar State in the west of India gave a table of the relationships between lepers, which shows some direct or collateral taint in only 30 per cent and none in the remaining 70 per cent of the tainted families 11 per cent showed brothers or sisters affected without any other family taint. He concluded that his figures would only indicate a hereditary taint if family contagion could be excluded and in a later paper he stated that he was convinced that the disease was a communicable one, but not to any extent hereditary

Ehlers of Copenhagen reported in 1897 the results of his inquiries on heredity in the very favourable field afforded by the small and well-educated population of Iceland, where the greater part of the leprosy patients had never quitted the country He found that only 56 out of 119 had leper relatives namely one or both parents in 22 brothers and sisters in 20 and grandparents in 14 generally the disease had declared itself in the parents long after the birth of the children and thus was only pseudo-hereditary

the evidence being more in favour of contagion than inheritance. Of the 63 lepers without leper parents contagion was possible in 43 and probable in 16 in 4 it was of marital origin.

It may be observed that nearly all the recorded data in favour of the hereditary origin of leprosy belong to a period when the leprosy bacillus was either unknown or not recognized as the causative agent of the disease. At that time so general was the acceptance of the theory of heredity and the disbelief in the communicability of the disease that the possibility of family infections explaining the incidence of the disease was often not even considered and was never excluded At the present day when the communicability of leprosy from one person to another either directly or indirectly is so fully established, the onus of proof is on the other side before cases can be considered as evidence of heredity the possibility of infection must be excluded. Important data bearing on the hereditary question based on a study of the abundant material in the Culion leper settlement in the Philippine Islands, were recorded by Rodriguez in 1926 Of 871 children born at Culion since its opening in 1906 records of the 398 survivors were analysed 42 per cent showed signs of leprosy infection including 24 4 per cent with only suspicious symptoms. The age incidence showed a great rise between 10 and 16 years of age, mainly attributable to lowered resistance at puberty and 50 per cent showed first symptoms between 3 and 6 years of age with an average of 5 years and 9 months. Not a single one of the 871 children born at Culion showed congenital infection and there was no evidence of hereditary leprosy Denecke reported that in West Africa the proportion of the children in families who developed leprosy was about the same when both parents were infected as when only one had leprosy he concluded that all the known data are against hereditary transmission.

Hereditary Predisposition.—The question of hereditary predisposition was also carefully studied in the Philippines but no conclusive evidence either way could be obtained If it occurs at all its role in disseminating leprosy must be a very minor one On the other hand Simons, working in the Dutch East Indian Molucca Islands, came to the conclusion in 1933 that the frequency of cases in certain families can best be explained by a theory of inherited congenital disposition Aycock in America also supported this view but H. W Wade concluded after a discussion of the subject, that only experimental investigations on animals susceptible to leprosy can afford definite evidence on the point. Among older writers Virchow and Liveing believed in a

The one discordant note was the report of the Indian Leprosy Commission appointed in 1889, the leading member of which was the strong anti-contagionist authority nominated by the Royal College of Physicians of London, Bevan Rake of Trinidad. He maintained the ingenious view that cases of apparent infection occurring in an endemic area were of no evidential value, for it is obviously very difficult to find cases originating elsewhere, but he admitted that the Dublin Benson case (p 83) afforded strong evidence of infection The Commission adopted his view that leprosy originated *de novo* this was merely a confession of complete ignorance of the causation of the disease in spite of the then proved constant presence of the leprosy bacillus. This finding was rejected by the influential Committee that had appointed the Indian Commission, and every international and other important leprosy conference from 1897 to the present day has practically unanimously endorsed the view that leprosy is a communicable disease.

Nevertheless the precise manner in which the causative organism passes from the diseased to infect the healthy is still unsettled. Important light may be thrown on the subject by a consideration of data from the vast literature, including a study of 700 cases collected by Rogers in which the probable source of infection was traced as a basis for the study of prophylactic measures (p. 80)

DIFFICULTY IN TRACING LEPROSY INFECTIONS

Long Incubation and Latent Periods.—Some authorities place the usual incubation period between the reception of the causative bacillus in the tissues and the development of the first symptoms at from 6 to 8 years. Cases are on record in which it apparently lasted one or two decades, but it is now generally believed that in such instances slight latent infections have been overlooked and an exacerbation following some debilitating disease has been mistaken for the first clinical signs of the disease. It only requires a moment's consideration to show how such long intervals between exposure to infection and the appearance of definite symptoms of the disease greatly increase the difficulties in tracing the source of infection, as compared with the few days incubation of most of the infective diseases. Would it be easy to trace the spread of small pox and to prove it to be an infective disease, if its incubation period was as long as that of leprosy?

The Slow Development of the Disease and the natural tendency for patients to hide their condition as long as possible for fear that its discovery might lead to lifelong incarceration without

hope of amelioration, still further adds to the difficulty of early diagnosis and tracing of the source of infection especially when that source is a relative, who may have hidden his or her condition. The great difficulty in finding cases in the early stages is well brought out by Hansen's experience in Norway From 1851 to 1870 the percentage of cases detected during the first three years of the disease varied between 18 and 24 in Bergen and Stavanger and between 4 and 22 in other areas. If such was the case in a European country with a good sanitary service it is not surprising that in backward tropical countries, with few qualified medical men and highly suspicious races to deal with, insuperable difficulties are frequently encountered in tracing the origin of any given case of leprosy Fortunately several instances of its introduction into previously uninfected civilized countries have furnished conclusive data, which are worthy of narration here.

Evidence of Group Infections in Newly Contaminated Countries.—

The Cape Breton Outbreak was reported in 1881 by Fletcher who laboriously investigated it. Betsy McCarthy was born and lived on Prince Edward Island close to the Canadian mainland where the Trecardie leper asylum is situated. At the age of 52 after the birth of all her children, she developed leprosy and died of it in 1864 five of her children, aged 20 12 10 12 and 20 all males except the last, contracted and died of the disease subsequently to their mother The daughter married John Dale, who died of leprosy six years later and two of their daughters, grand children of the first patient, also died of the disease. A man, who attended the fourth son when ill of leprosy and laid out his body had leprosy soon after and died of it. James Cameron married a healthy daughter of Betsy McCarthy and had two healthy children. He was accustomed to sleep with the fourth infected son and he developed leprosy in 1870 and was very ill of the disease in 1880 Thus five children and two grand children of the first patient contracted leprosy as did three males unrelated to the family but living with them during the illness of some of the family although there were no other known cases on the island at the time this is a most conclusive example of repeated house infections after long contact with leprosy cases.

The Louisiana Epidemic is equally striking and has been fully recorded by White. Leprosy was known in Louisiana in 1785 but apparently died out. The next known case occurred in 1866 in a Frenchwoman who died of leprosy in 1870 Three of her four

sons and one of two daughters developed leprosy in 1871–2 they all lived in the same small town. Next a nephew living eight miles away but frequently visiting the family developed leprosy in 1875, and in 1873 a young girl, not related to the family but who nursed the first patient during the last stages of her illness, showed signs of the disease three years after the death of her leprous patient. Lastly a young man unrelated to the family but who had frequently slept during 1875 *with the fourth infected son* developed leprosy in 1877 Thus, within eleven years the first patient, who had extensive ulceration had given rise to leprosy in four children and one nephew while two persons living with the infected cases but not related to them, had also become infected although no other cases were known in the country when the mother of the family developed leprosy Other cases subsequently appeared in the neighbourhood and the disease has continued to the present day

Such histories furnish conclusive evidence of the communicability of leprosy through prolonged close contact with the diseased—much more so indeed than any number of apparent infections in countries where leprosy has long been endemic.

Memel Outbreak in East Prussia.—Equally conclusive are the details of the outbreak of leprosy in the Memel district of Germany carefully worked out by the chief medical officer of the district. The infection of each group of cases was traced to Russian female leprosy cases who came to reside in the district as domestic servants with the results briefly summarized in *Table VI*

Table VI—The Outbreak in the Memel District

Group	Date of First Case	No. of Cases	Last Case	Cases Remaining in 908
1	1848	96	1891	0
2	1856	12	900	1
3	1860	16	1908	8
4	1863	15	1906	5
5	1880	10	1903	

Thus in every group the initial case was a Russian from the neighbouring long infected Baltic provinces, who had come to the Memel district as a domestic servant, and it was clearly established that infection nearly always occurred only after long contact with a leprosy case living in the same house the following are typical examples. A Russian peasant servant came to live in a house and during the next four years the father and all three

children became infected it next appeared in a friendly family where the mother three children, one female servant and the second husband of the infected woman were all attacked. A third family was infected from the second and the father son two daughters daughter in law one maid-servant and two men servants were all attacked by leprosy On the other hand many families remained long with a single leprosy patient as the infectiveness of different cases varied much. No less than 69 of the 77 cases were of the nodular and mixed varieties and only 8 purely anæsthetic. All the cases from whom infection was traced were nodular ones—a very significant fact to which we shall return (p 70) Of the 16 cases remaining in 1908 11 were in the leprosy asylum while several little if at all infective nerve cases were at their homes under medical supervision the outbreak was on the decline following prophylactic measures adopted in 1899 although previously to that date the number of cases had increased steadily in each five yearly period

Examples of the Spread of Leprosy following the Introduction of the Disease among Tropical Races in a Low Stage of Civilization.—Although it is usually far more difficult to trace in detail the spread of leprosy among tropical than in European races, yet the following examples serve to illustrate its rapid spread among such communities when the disease is first introduced among them.

Rodriguez Island Outbreak—A fisherman named Diango went from Mauritius to live on the neighbouring island of Rodriguez, and developed leprosy four or five years later From what transpired he must on his arrival have been in the incubation period of leprosy seeing there were no previous cases in the island When the disease was clearly developed he went to live apart on a mountain four miles away A year or so later his former employer's son with whom Diango had worked on the same boat, showed signs of leprosy Up to 1920, forty or fifty years after Diango's landing 23 cases had occurred on the island, 16 of whom were the descendants, either direct or through marriage, of the family of the second case, and the remaining 7 of Diango himself. During the last seven years there had been 5 deaths from leprosy and 7 new cases.

Introduction of Leprosy into Natal.—In 1843 two natives returned to Natal from the Cape, where they had each lived with a native leper woman for three years. On their return they each married a healthy native woman. Two years later both the returned men developed leprosy and one died within three years of a very acute

attack. From the kraal thus infected the disease spread from tribe to tribe and by 1895 all were infected although the first infected tribe was involved to the greatest degree. A Government inquiry in 1886 revealed that over 100 cases had arisen from the two imported forty three years before by 1895 132 additional cases had been reported making over 200 in all (Impey)

In *Colombia*, Montaya reported the case of a merchant infected from a negro slave in a town previously free from leprosy thirty-three years later there were 67 known cases derived from him in the town.

Nauru Island Epidemic —This small Pacific island was first infected during the German occupation in 1911 or 1912 through a Gilbert Island woman, recognized as a leper by the doctor but allowed to land by the Governor (Morgan, 1925) From 1918 to 1920 four cases of leprosy were recognized, three died during the influenza epidemic and the survivor became an advanced nodular case. By 1922 there were 34 cases all but one Nauruans and 9 of them relatives of the survivor of the 1918–20 group and 3 more were relatives of one of those who died during the epidemic. No case was found at this time among the Chinese or Europeans, who lived apart from the Nauru Islanders The 34 cases were distributed in three groups 16 had originated from a batch of 4 early cases, another 13 from a second group of 5 cases, and the remaining 5 were in a detached central district The only other cases that had occurred on the island were those of two Chinese immigrants living apart from the Nauru Islanders they were repatriated and did not infect other Chinese There thus appears to be no doubt that this serious epidemic, which by 1927 was found on close examination to have infected 30 per cent of the native population (p 137) originated from the unfortunate overruling by the civil authorities of the doctor who at first had prevented the infected Gilbert Islander from landing Once more it is demonstrated that in a small closely supervised community the spread of leprosy from an infective immigrant was easily traced this leaves no possible doubt regarding the communicability of the disease or of the necessity of protecting healthy communities by excluding or repatriating leprous immigrants (p 139)

CHAPTER VI

CONDITIONS INFLUENCING THE CONTAGIOUSNESS OF LEPROSY

Before considering in greater detail the conditions under which leprosy has been most frequently communicated from the diseased to the healthy there are certain facts greatly influencing the infectiveness of the disease which must carefully be borne in mind in relation to individual cases

THE FAR GREATER INFECTIVENESS OF LEPROMATOUS AS COMPARED WITH NEURAL CASES

The data given in the bacteriological section (p 152) afford good grounds for believing that lepromatous cases, including the mixed forms with both nodules and nerve lesions, are much more frequently the origin of new infections than the neural type. These data show the copious discharge of the bacilli from ulcerating nodules and the very large percentage of lepromatous cases in which abundant discharge of the organisms occurs in the nasal mucus, as compared with the absence of lepra bacilli from the perforating ulcers of neural cases and their comparative infrequency in the nasal discharge of such cases. This conclusion is abundantly confirmed in recorded literature.

Thus, Dehio quotes Lokh's figures showing that in two parishes among 48 nodular cases 36 70 per cent, had in all probability been sources of infection yet in 13 nerve and mixed cases no suspicion of spread from them had arisen. Again, in the Sögn district of Norway there were 36·6 per cent of nodular and 43 4 per cent of nerve cases and the number of additional new cases varied between 8 and 10·8 per cent but at Soendfiord with 72·6 per cent nodular and 27 4 per cent of nerve cases, the percentage of new cases varied between 14 4 and 19·5 Thus the new cases varied closely with the percentage of the infective nodular cases in each place Dehio and Lokh therefore concluded in 1897 that nodular leprosy is an infectious disease, whereas maculo-anæsthetic leprosy is caused by infection through the *Bacillus lepræ*

or the leprosy virus, but is not in itself, or only to a slight degree, contagious Hansen and Kaurin of Norway also held that nodular cases were most infective and that this form preponderated in Norway when leprosy was reported to be increasing In some of the instances of the most rapid extensions of leprosy nearly all the cases were of the nodular form, as in Hawaii, the Loyalty Islands and New Caledonia. Cochrane (1935) has reported that in St. Kitts Island every case of nodular leprosy whose contacts had been examined had infected from one to three children.

Again, in 1935 Christian reported that at the Dichpali leprosy hospital in India none of 23 children in eleven families with one parent suffering from the little-infective neural form had contracted leprosy but when one or both parents suffered from the infectious cutaneous type no less than 101 (90 per cent) of the 110 children showed definite signs of the disease. In the Belgian Congo Degotte found that in 43 per cent of foci of infection the appearance of a lepromatous case had been quickly followed by an extension of the disease.

Lastly in 113 of the 700 cases collected by Rogers (*see Table X* p 80) in which the probable source of infection was traced this source was nodular in no less than 107 or 94 7 per cent only in the remaining 5·3 per cent was it a nerve case. These are very conclusive figures.

Neural cases with discharge of bacilli from the nose, which form a small minority of the whole (p 152) cannot, however be looked on as completely harmless, although far less dangerous than nodular ones

VARIATIONS IN SUSCEPTIBILITY WITH AGE

There is now general agreement that children and young adults, particularly about the age of puberty are especially liable to develop leprosy Over the age of thirty years the liability to contract the disease when exposed to contact with leprosy cases decreases although no age period is entirely exempt.

Most of the recorded data only note the dates of detection of the disease or admissions to leper asylums, and not the date of the onset of the disease. In the data used in preparing *Table VII* the ages at which the disease was first noticed were carefully recorded As such figures do not indicate the ages at which the actual infection with the leprosy bacillus took place, it was necessary in order to get at least approximate figures, to deduct the average incubation or latent period, which may be placed at three to five years (p 163) The estimated ages at which infection probably

TABLE VII.—PROBABLE AGE OF ONSET (PERCENTAGE INFECTED AT THE AGES GIVEN)

District Affected	Age of Patients in Years							
	0–5	0–10	0–15	0–20	0–25	0–30	0–35	Over 35
South Russia (Munch)	6·10	19·40	37·20	54 70	65 50	73·50	80·00	20·00
Indian Commission	8 85	19·59	32·70	47·36	63 11	73 41	83 33	16·47
Vandyke Carter M	—	—	4 70	31 40	65·30	86·10	93·60	—
Vandyke Carter F	—	—	20·00	49·30	76·50	93 70	97 10	—
Molokai (McCoy)	6 10	[illegible] 50	40·70	54·70	65·00	72·50	80·90	19·10
N. Nigeria and Soudan (Tonkin)	25 43	39·08	59·08	75·17	80·89	84·98	89·43	10·57

occurred are arranged so as to show the percentages of total infections which had taken place up to the end of each age period and those which occurred after 35 years of age. The figures of the Indian Leprosy Commission and those of Vandyke Carter were obtained by deducting five years for the incubation period from their figures showing the ages of the onset of the disease. The figures of Munch for South Russia were estimated by deducting three years from the date of onset.

The general results of the four sets of figures in *Table VII* are remarkably parallel especially in the case of the ages from 0 to 20 up to 0 to 35 years. As they are derived from some 4000 cases they afford a firm basis for concluding that in approximately 50 per cent of the cases the infection occurred between the first and the twentieth year of life, 67 per cent originated before the end of the twenty fifth year 75 per cent by the thirtieth year and over 80 per cent by the thirty-fifth year This leaves under one fifth at subsequent age periods, although the disease has been known to develop after 80 years of age At ages below 20 the figures of three of the reports are also closely similar namely 6 to 8 per cent below 6 years of age, 19 to 21 per cent up to 10 years, and 33 to 40 per cent up to 15 years

The figures of Tonkin for highly infected Nigeria and the Sudan show considerably earlier infection namely no less that 39 per cent by the age of 10 years, 73 per cent by 20 and 85 per cent by 30 years of age. It is of interest to note that these very early infections occurred among negro races with at least ten times as high a leprosy rate per mille and a lower stage of civilization than those of India. Tonkin also noted that the average age of the appearance of leprosy in 52 cases with other cases occurring in

the family was only 13 26 years, but among 167 patients with no other case in the family the average age of the appearance of the disease was 20·83 years thus shows earlier development with greater exposure to infection.

In the Bankura district of Bengal 61 per cent of the cases were found to have originated early in life. R. G Cochrane in Madras found house and familial contact the most important factor in infection no less than 69 7 per cent of leprous children had been in contact with an open case and 70 open or lepromatous cases of leprosy had infected 141 children Among adults in the same families only 18 to 22 per cent became infected

EVIDENCE OF THE SPECIAL SUSCEPTIBILITY OF CHILDREN TO LEPROSY

Many authorities consider children to be especially liable to infection through close association with lepers they include Lie of Norway Ehlers and Verdier who state that children are in the greatest danger of infection while living in a house containing a leper and Dohi of Japan. Veendam in British Guiana met with cases in children over 4 years, who are sometimes infected by nurses and servants, and Dalziel in Sokoto found cases in grand children of 6 to 9 years negro children being commonly brought up by their grandparents while their parents work. Arning found 8 cases, 7 27 per cent, among 110 schoolchildren he examined in two Hawaiian schools.

Denny's extensive statistics of the Philippines showed 16 4 per cent of infections among children aged from 1 to 10 years and as many as 44 per cent in those who had lived with leper parents for 7 to 10 years, that is, over the usual incubation period of the disease. Further figures from the Culion leper colony up to February 1922 showed infection of 14·2 per cent of 308 children born in the colony and not separated from their leper parents and 18 8 per cent more with suspicious signs of the disease bringing the total of probable infections up to 33 per cent. Denny observed that the number of infections increased with the duration of exposure in children under 5 years only 2 per cent became undoubted cases from 5 to 9 years 12 per cent, and between 10 and 13 years of age no less that 36 8 per cent had been attacked—very serious figures demanding adequate preventive measures. Once more, Velasco in 1934 reported from the Manila hospital that out of 27 adults with 125 children, 80 were examined, and of these 61 76 3 per cent, were leprous mostly early cases for only 22·9 per cent were bacteriologically positive. In Surinam however

Lampe in 1933 reported that only 26 per cent of 69 children of lepers who survived the first year of life developed leprosy some of whom he thinks were infected after leaving the asylum

Sand and Lie have also recorded evidence of the great suscepti bility of children in Norway Their combined figures relating to 2010 children of 587 couples showed 7 per cent of the children infected when the father alone was a leper 14 per cent when only the mother was diseased and 26 per cent when both parents were lepers Vandyke Carter in India found earlier development of leprosy in badly infected districts namely 16·7 per cent who had developed leprosy during childhood while elsewhere there were only 9 per cent he also noted the later age of onset of nerve cases which may be explained by longer incubation and the more frequent *occurrence of the milder and slowly developing neural form in* persons infected at a period of life when their resisting powers against infection are greater He mentioned that nearly all cases under 20 years of age had infected relatives. At Tarn Taran in the Punjab leprosy was found to appear largely in childhood or early youth the average age of onset of 105 cases was 16·25 years (Abrahams)

Hollmann gives data from Honolulu showing increasing per centages of infections in children with longer periods of contact
parents (p 163) The average time of exposure
ing leprosy was five years and the average period
it after cessation of exposure was also five years.
in South Russia found that when there was more
eprosy in a family 45 per cent of the cases occurred
and among brothers and sisters. In 1857 in
cent of 145 children born in the leper asylum
r suspicious signs of the disease (Drognant
he same area Lampe in 1933 found symptoms
traced children who had survived over one year
the disease developed from the fourth to the

CONCLUSION

bundantly show that children and young adults
age are most susceptible to the infection of
ly infections are especially frequent when there
living in the same houses as healthy children
widely prevalent, thereby affording greater
ose association with lepers these facts are of
nce in relation to the prophylaxis of leprosy

FREQUENCY WITH WHICH INFECTION CAN BE TRACED AND ITS SOURCES

The great difficulty in tracing the source of infection of leprosy, with its very long incubation period and often slow development, has already been pointed out (p. 64). To this must be added, in those countries where attempts at compulsory segregation have been made, the custom of the patients, denying the existence of any leper relatives, who might otherwise be discovered and isolated. Nevertheless wherever careful inquiries have been made, in a considerable percentage of known lepers one or more leper relatives or close associates have been traced from whom their infection may possibly have been derived: this is proved by the data shown in *Tables VIII* and *IX*. The figures range from 29 per cent in Denny's large Philippine series, in which only leper relatives were counted, to 89 per cent in the Caucasus. The lowest percentages are in the large series of cases in the Philippine Islands and Hawaii, where the figures were compiled from incomplete records over a number of years and where active segregation

Table VIII.—Frequency with Which Infection can be Traced, and its Sources

Country	Observer	Total Cases	Lepers acknowledging Contact with Leper Relatives	Parents Lepers	Brothers or Sisters	Relatives by Marriage	Proportion of Lepers acknowledging Association with other Lepers before Infection	Conjugal Relations Proportion Infected	Contact Infections following House Contacts
			per cent	per cent	per cent	per cent	per cent	per cent	per cent
Cape Colony	Gregory	568	33·3	—	—	—	—	—	—
Hawaii	McCoy	1,058	37·0	—	—	—	—	2·64	4·5
Do.	McCoy (M.)	119	—	—	—	—	—	5·1	2·2
Do.	Goodhue (F.)	106	—	—	—	—	—	4·8	4·7
Philippines	Denny	10,000	29·0	—	—	—	—	—	—
Indian Leprosy Commission		—	—	—	—	—	—	6·5	5·6
Tarn Taran	Abrahams	118	35·6	17·0	12·8	4·2	—	1·7	—
Basutoland	Long	181	—	16·6	—	—	79·6	5·0	—
Japan	Kitasato	—	—	7·05	4·0	—	—	3·8	2·7
Caucasus	Karevel	100	—	—	—	—	89·0	—	—
Russia	Dehio	—	—	—	—	—	60·0	—	—
Norway	Lie and Sands	—	—	10·3	4·0	—	—	3·8	2·7
Texas, U.S.	Boyd and Warren	—	—	—	—	—	60·0	—	—

measures had led to cases being hidden the patients having a strong incentive not to acknowledge that their relatives were lepers. They are higher in small series carefully investigated by the actual reporters in which contacts are included consequently these are more likely to be approximately accurate. Under such

Table IX—Percentage of Different Relatives from Whom Infection was Traced

	Total Cases	Grand-parents	Parents	Brothers and Sisters	Cousins	Uncles and Aunts	Younger Generation	Conjugal	House Infection	Associates
Hawaii (McCoy)	316	1·89	37·02	32·27	5·69	7·59	6·63	8·85	—	—
Philippines (Denny)	2,221	0·49	11·30	35·61	27·10	9·42	14·26	1 80	—	—
Romania (Babes)	144	—	27·77	26·39	—	6·25	—	5·50	5·5	5·04

comparatively favourable conditions in 60 to 89 per cent a history of possible infection from another case can be traced—a very high figure for a disease with such a long incubation and latent period Rodriguez and Plantilla (1934) by house to-house inquiry among 3130 persons in the Philippines traced previous contact with a leper in 80 per cent of open bacteriologically positive cases and in 68 per cent of closed bacteriologically negative ones 44 per cent and 3 per cent respectively had lived in the same house as a leprosy case. In Bengal K R. Chatterji found house infection in 54 7 per cent and association with a leper in 22 8 per cent, making a total of 77 5 per cent. Muir (1923) traced previous contact with lepers in 58 per cent of infections, mostly house ones from parents and grandparents

In the course of a survey of 10,000 persons in Bengal villages Lowe (1938) obtained a *definite history of contacts* in over 80 per cent, mostly with open cutaneous cases. One third were infected by near and another third by distant relatives the latter are often due to the Hindu joint family system of three generations living in the same house.

THE MOST FREQUENT SOURCES OF INFECTION

From Affected Relatives.—In the case of the Philippines, Romania, Tarn Taran asylum in the Punjab province of India and Basutoland data are available regarding the relations from whom the infection was most probably derived from these the percentages shown in *Tables VIII* and *IX* have been worked out.

The most striking feature is the frequency with which the infection was derived from a blood relation as compared with conjugal infections The explanation becomes apparent when the actual relationships are considered, for it will be seen that the majority reaching as high as 73 per cent in the Philippine and 54 per cent in the Romanian series, were infections of children from parents and between brothers and sisters or cousins, nearly all of which are likely to have taken place during the highly susceptible first two decades of life The number of house infections in unrelated persons varied between 2 and 5 per cent.

At the Robben Island leper asylum of Cape Colony Gregory obtained a history of 33 3 per cent of 568 patients having one or more leper relatives the numbers were, in 67 cases 2 relations, in 48 cases 3 in 33 cases 4, in 32 cases 5 in 6 cases 6 and in the remaining 4 no less than 7 infected relatives In Fiji Austin (1932) found that 81 of 105 patients gave a history of a leper relative.

A number of infections are frequently found in one family Thus, in Fiji Neff (1929) reported an Indian family in which a son contracted leprosy from a neighbouring friend from him his father mother and five of his six brothers and sisters became infected, and only one child who left the household early escaped the disease. Muir (1934) found that of 17 children in six families, who had lived up to six years with an infectious case of leprosy 10 had developed the disease he has also noted that the younger the age of infection the more likely is the child to develop the serious cutaneous type. Wayson and Rhea (1934) record finding 3 or more cases in 10 per cent and 2 or more in 30 per cent of infected households. The Medical Officer of the Cayman Islands in 1936 recorded a family tree tracing the successive infection of 11 relatives and 4 contacts between 1825 and 1904.

The practical importance of these data will appear under prophylaxis

Frequency with which Healthy Persons Residing in the same House or in Conjugal Relationship with a Leper contract the Disease.—The data on this important point are derived mainly from the Hawaiian records of McCoy and Goodhue (*see Table VIII*) the figures in both classes varied between 2 and 5 per cent. It is noteworthy that those of McCoy and Goodhue, giving the data for males and females separately present almost similar figures for conjugal infections, namely 5 1 for males and 4 8 for females but the house infections show 2·2 for males and 4 7 twice as high, for females. This is explainable on the ground that women spend more time at home on domestic duties in close

approximation to the leprosy patients who have an especial incentive to shut themselves up in their residences in countries such as Hawaii where active segregation measures have long been in force Kitasato gives very similar figures for Japan, namely 3 8 per cent of conjugal and 2 7 per cent of house infections. McCoy and Goodhue record that in 1886 to 1888 at the Molokai leper settlement of the Hawaiian Islands no less than 16·4 per cent of the healthy persons living in the settlement chiefly in conjugal relationship with lepers, became infected Mouritz in 1886 reported that he had examined 178 healthy Molokai attendants, mostly married to lepers in February 1885 and again in February 1886 and he found that no less that 17 9·5 per cent, had developed leprosy in twelve months. Conditions in the settlement at that time were very bad and subsequently with improved care such infections greatly decreased

The comparative infrequency of conjugal infections has been fully confirmed by recent observations. Thus Muir (1923) in India found only 2 9 per cent of traced infections of this nature. Simons (1933) in the Molucca Islands investigated 157 marriages where one or both parties were lepers and found that in 19 both had been affected before marriage and only 2 could be regarded as having been contracted after marriage Bechelli (1936) in Brazil traced conjugal infections in 9·7 per cent of 506 cases, nearly always in the earlier years of cohabitation

The type of the infecting leper is important, for Doull and others (1936) report from Cebu, Philippine Islands, that before infection previous contact with a leprosy patient, at least as intimate as sleeping in the same house was met with in 38 5 per cent, and family contact in 26 per cent, of the investigated cases and in all but two instances the antecedent leper was known to have been bacteriologically positive

Distribution of Lepers in an Infected Country—Numerous observers have found that leprosy is not regularly distributed in any infected area, but tends to occur in groups in certain villages while neighbouring ones entirely escape the disease. Thus Lokh, in the Baltic island of Oesel, with long present but sparsely prevalent leprosy in a scattered agricultural population, found that the cases were not regularly distributed but were for the most part crowded in certain villages, farms and families in definite foci with constantly recurring evidence that lepers, before the appearance of the disease, had lived in more or less close contact with lepers In 19 instances the attacked person had shared the same bed with a nodular leper and 27 were infected after sharing

to those among the general population is less. Further in the Philippines Plantilla (1935) found 32 per mille infections among contacts with other lepers but only 2·6 per mille among 13 586 schoolchildren representing the general population. A survey in Cebu, Philippines, showed a history of previous house contact in 35 to 37 per cent. In the Bankura district of Bengal 80 per cent of new cases gave definite evidence of previous contact with leprosy of an infectious type: in 50 per cent through living in the same house and in 30 per cent through extra familial contact. In Cebu Doull found that the annual risk of contracting leprosy is about five times as high with as without house exposure. At Batavia, Dutch East Indies, house-mate infection was traced in 52 per cent of cases. In Panama contact infection was traced in 74 per cent of cases: the disease was mainly a familial one. Among 116 new cases visited either in hospitals or in their homes, in all but one prior contact with a leprosy case was established. In the United States 96 per cent of native born cases could be allocated to known areas of prevalence of the disease: out of 396 stationary patients only 4, 1 per cent, failed to give a history of contact with a source of leprosy. It thus appears that the more advanced a country is socially the larger proportion of cases in which the source of infection can be traced.

THE CONDITIONS UNDER WHICH LEPROSY IS MOST FREQUENTLY CONTRACTED

The literature of the last seventy years teems with recorded examples of various conditions under which leprosy appears to have been communicated from the sick to the healthy. The exact mode or modes by which the lepra bacillus passes from the diseased to infect the healthy are still, however, obscure and the conditions under which the disease is communicable can best be studied by an analysis of a large number of recorded cases in which the probable source of infection was traced. For this purpose Rogers has collected 700 cases from the literature of some five decades and embodied the results in *Table X* which may serve as a basis for the discussion of this difficult aspect of the leprosy problem.

CONJUGAL INFECTIONS, INCLUDING COHABITING OF UNMARRIED PERSONS

These close relationships account for respectively 85 and 43 of the 700 cases, a total of 18·28 per cent, almost one-fifth of the whole number. This is especially noteworthy in view of one of the stock arguments of the anti-contagionist having been the

rarity of such infections. The great majority of cases of cohabiting occurred in tropical countries where men have frequently been attacked with leprosy during or within the common incubation period of the disease after living with leprous native women. In rare cases the disease has apparently been contracted by sexual relationship with a leper woman on a single occasion in three of these the symptoms appeared respectively ten months, one year and two years after such exposure to infection. In at least one the man was under the influence of alcohol at the time.

Table X.—700 CASES IN WHICH THE PROBABLE SOURCE OF INFECTION WAS TRACED

MODE OF INFECTION	NUMBER	PERCENTAGE	
Conjugal	85	12·14	18·28
Cohabiting	43	6·14	
House	180	25·7	39·84
Room	35	5·0	
Bed	64	9·14	
Attending on lepers	139	19·87	
Leper playmate	23	3·28	19·42
Close association with a leper	113	16·14	
Wet-nurse	8	1·14	
Wearing leper's clothes	3	0·43	
Vaccination	4	0·59	
Inoculation from a leper	3	0·43	

Explanation of the Comparative Rarity of Conjugal Infections.—Nevertheless, the frequently recorded opinion of experienced leprologists that conjugal infections are rarer than might be expected from such close intimacy is correct, for we have already seen that only from 2 to 6 per cent of persons living in such relationship to a leper contracted the disease. That is very much the same proportion as in the case of persons living in the same house with a leprosy patient.

In the first place most married persons at the time of exposure to conjugal infection will have passed the most susceptible age. Secondly the most infective nodular form of leprosy commonly involves the testicles and decreases or ends the sexual powers of the male. Thirdly when one partner develops leprosy by the time the disease reaches the infective stage conjugal relationships commonly cease. Thus, Lewis in India found in many cases the leprosy-affected husband or wife living alone in a hut outside the family house, and Munch related that in South Russia an infected wife is frequently turned out of the house and cohabitation stopped

In these various ways the relationship of many persons married to a leper is reduced to much the same degree as that of house or other contacts this explains the very similar frequency of conjugal and house infections shown in the last two columns of *Table VIII*

The numerous recorded cases of infection of males through cohabiting with leprous females are easily understood as here the male being the healthy partner the conjugal relationship involving the most intimate contact will be continued with great risk of infection especially if the female is suffering from the lepromatous type and has lepra bacilli in her nasal discharge.

Can Leprosy be Transmitted by Sexual Intercourse?—It is remarkable how widespread in tropical countries is the belief in the sexual communication of leprosy The Chinese held that males are often infected in this way while the Chinese women believe that they may get rid of the disease by selling it to a male through sexual intercourse, and they even go out after dark for this purpose (Cantlie) In Africa the natives of Madagascar and of North Nigeria (Dalziel) hold the same belief and Thiroux quoted Leloir Clacac and others as in agreement with the possibility of this mode of communication of leprosy Nor is bacteriological evidence in support of the possibility wanting for Babes and Kalindero reported having found numerous lepra like bacilli on the mucous membrane of the vagina and uterus as well as in human semen Gluck has noted leprosy lesions on the glans and prepuce as well as on the vulva. Thiroux himself examined the vaginal mucus of 100 leper women and found lepra like bacilli in 27·27 per cent of nodular and 3 84 per cent of anæsthetic cases making 9 per cent of both classes combined This, with the much higher percentage of positive results in the highly infective nodular than in the nerve cases goes far towards negativing the possible fallacy of the acid fast bacilli found being of the smegma variety On the other hand, Munro and also Pichon in New Caledonia considered that the close bodily contact might account for the infection without its being directly due to the sexual act. N C. Macnamara, however thought the not infrequent ulceration of the male organ might lead to the female being inoculated with leprosy during sexual intercourse and Kermorgant stated that in Cochin-China many wives are attacked through contagion from their husbands.

We may therefore conclude that, although it cannot be taken as proved that the infection of leprosy is actually conveyed by the sexual act itself, it is by no means unlikely that such may occasionally be the case, although very much less frequently than

the contagion of syphilis However that may be, there is no doubt that leprosy is often contracted either directly or indirectly by cohabiting of the sexes sometimes apparently on a single occasion, the close contact involved being very favourable for the transmission of the lepra bacillus from the diseased to the healthy partner especially through nasal discharge of the bacilli. Such infections may help to explain, firstly the increased prevalence following puberty and secondly, the great preponderance in adult males, as they are more promiscuous than females in their sexual activities. Further the exceptionally high incidence among the women of Galicia already mentioned (p 21) is attributed to their irregular sexual habits during the long absence of their husbands as is the extraordinarily rapid spread in such countries as Hawaii where the women are reported to be so promiscuous that they seldom know who are the fathers of their children

HOUSE, ROOM AND BED INFECTIONS

The largest number of cases in *Table X* come under this heading with 39·84 per cent, two-fifths of the whole clearly constituting the most frequent conditions under which the disease is communicated from the healthy to the sick. In 9 14 per cent, almost one-fourth there was a definite record of the infected person having slept in the same bed as the leper from whom the disease was contracted, although no conjugal or cohabitating cases were included This brings bed infections up to 27 44 per cent, over one-fourth of the whole series, and in another 5 per cent the same room was occupied Nor is this all, as room and bed records were only obtained in the case of the more highly civilized races, but among the poorer and more backward tropical people it is the general rule for the whole family to live in one-roomed huts, and sleep the diseased with the healthy upon one mat and under one tepa, or bark woven covering" (Arning Hawaii) This applies to most of the inhabitants of India, China, Oceania, Africa South America and numerous tropical islands infected with leprosy Even in such a country as Norway Hansen recorded that in many of the leprosy-infected houses it was customary for the men to sleep all under one coverlet in one room and the women in another room, and he stated that when in certain festive seasons farmers families visit each other for dancing and stay the night it is considered exceedingly rude to refuse to sleep in a bed with a person who is slightly leprous Again in Hawaii guests are reported to be entertained by the company occupying one large bed spread on the floor and one or more families commonly

occupy the same bed. In Riga the admission of five lepers to the leprosarium from charitable institutions led to a search which revealed 31 in all who had been attacked within three or four years after the admission of four lepers to these institutions.

Of the 25 7 per cent of house infections 11 per cent occurred in tropical climates where they must have been almost all at least room and frequently bed infection cases. If we take two-thirds of the 11 per cent to have been so this would bring the bed infections up to at least one third of the total 700 cases—a very significant figure which indicates that prolonged close contact is commonly necessary to enable the disease to be transmitted. This is a fact of the greatest importance in relation to prophylactic measures

Under good sanitary conditions in the temperate zone leprosy infections are very rare, but in 1877 Dr Benson recorded the case of an Irish soldier who developed leprosy a few months after his return to Dublin from twenty two years' tropical service and died after a year and a half. During this period his brother slept in the same bed with him and wore his clothes, and although he had never been out of Great Britain he developed nodular leprosy Juan de Agua recorded that in Spain a man with leprosy infected successively two brothers who had slept in his bed for two years and three to four years respectively

Household Servants and the Spread of Leprosy—The importance of house servants in spreading and maintaining the prevalence of leprosy has frequently been pointed out and we have already seen how extensively the Memel district of Germany was infected by the introduction of leper domestic servants from Russia (p. 66) Further evidence on this point is furnished by Dehio, who reported cases of infection from servants in Russia and also from unrelated persons inhabiting the same room. He concluded that leprosy is not solely a family disease, but one of the household and of close intercourse poverty forcing the healthy and the sick to share a room or a bed. Landré records no less that twelve cases of pure-bred European children being infected with leprosy by leper servants, wet nurses or playmates in Dutch Guiana alone. In Sweden Sederholm found that the attacked were "either children, relations, or servants or such persons who frequently visited families residing in the houses where the illness had been" Veendam, in his twenty-seven years experience in British Guiana, repeatedly found lepers as servants and nurses from whom children were infected. Muir found a lepromatous case serving in a high-class Calcutta restaurant

THE INFECTION OF ATTENDANTS AND ASSOCIATES

Infection of Attendants.—In view of the frequent assertions of anti-contagionists a few decades ago that the disease could not be communicable because attendants on lepers were very rarely attacked by leprosy it is interesting to note that no less than 139 of the 700 cases in *Table X* 19 42 per cent, fall under this heading Forty of these occurred in the two years 1886 and 1888 out of 244 healthy attendants living at the Molokai settlement of Hawaii, 16 4 per cent of them and a number of others are on record from the same country during the earlier decades of the settlement's existence. It is noteworthy that 3 of 23 European males were infected after three, nine, and seventeen years' residence in Molokai. They included Father Damien, who was notoriously careless regarding the danger of contact with the lepers but not one of the twelve sisters, who dressed the cases and were trained in methods of cleanliness, contracted the disease. There is no doubt that at the present day with the regular use of precautions attendants on lepers in well-regulated leprous institutions run very little risk of contracting the disease provided they are not intimate with the patients.

The cases of infection of attendants on lepers in the table include 33 4 74 per cent, who had nursed patients in their homes these were consequently also house infections. Many of the attendants infected at Molokai were also living with lepers so that including the conjugal cases something like 70 per cent of the whole series were house infections, and that, too in spite of many of the family infections of children having been excluded by the earlier writers on account of the hereditary theory then widely held.

Among the infected attendants on lepers regarding whom details are available were two doctors of leper institutions, at least one of whom *was notoriously careless in regard to cleanliness*, and three persons, including one nursing sister who washed lepers clothes Examples are also on record of three dressers, table servants and cooks of leper asylums having contracted leprosy

Close Association with Lepers.—*Table X* shows 136 cases, 19 42 per cent of the total, under this heading They include 23 cases of children who appear to have contracted the disease from leper playmates. Most of them were unfortunate Europeans in tropical countries who through the ignorance or carelessness of their parents were allowed to play with leprous native companions. Drognant Landré recorded a dozen cases in Dutch Guiana within thirty years of pure-bred European children becoming infected

from native lepers, and in French colonies European children have been infected from native leper servants (Delrieu Jeanselme, and Kermorgant)

Kaurin s experience in Norway brings out well the great frequency of infection through close association with a leper Of 95 admissions to the Molde hospital all but 48 had leprosy in their families and he states in most of these 48 cases I have been able to prove more or less intimate intercourse with lepers and it has been quite an exception to find a patient who assured me he had never come into contact with other lepers. I for my part am convinced that it is very seldom that we can find a leprous patient whom we cannot trace to have had intercourse with other lepers Jeanselme pointed out that in New Caledonia there were no cases of lepers among the white troops or among the French convicts who had no contact with the contaminated native tribes but among certain classes of convicts and galley slaves in the convict prison, who had intimate daily relations with the indigenous Canaques, leprosy prevailed greatly

In most of the cases regarding which details are recorded the healthy person frequently visited the house of the patient from whom he appears to have contracted the disease, and many of these cases had stayed in the leper's residence such instances were also house infections, which thus reach fully 80 per cent of the whole 700 cases. This establishes beyond doubt that as a rule very close and usually prolonged proximity with one or more lepers is necessary before the disease is contracted, although occasionally the contact may be of quite short duration, as in examples already mentioned of persons contracting leprosy through sleeping one night with a leper woman or in a native leper hut

The 8 cases, 1 14 per cent, of apparent infection from a wet nurse are of importance as indicating the necessity for care in the tropics to avoid such an occurrence.

INFECTION BY INOCULATION THROUGH THE SKIN

The sources of infection above dealt with afford important evidence of the conditions under which leprosy is most commonly contracted and the necessity for avoiding them as far as possible. They do not, however throw much light on the actual manner in which the lepra bacilli pass from the diseased to gain a footing in the bodies of the healthy a knowledge of which would be of the greatest advantage in formulating simple and efficient methods of prophylaxis The last three entries in the table under the respective headings of wearing leper's clothes vaccination

and inoculation include cases in which the infection was believed to have entered through the skin of the patients and thus are deserving of special consideration.

Infection through Wearing the Clothes of Lepers has frequently been suggested. Hansen reported the case of a young man becoming infected one year after he had worn a pair of old drawers given him by a leper and another who wore several pairs of his leprous father's stockings. Tonkin thought transmission through the skin by friction against body prominences, such as the temporal ridges, buttocks, etc. from clothing bedding and sleeping-mats infected with the discharges of lepers to be a common mode of infection in the Sudan, where clothes are never washed but are sold from the richer to the poorer until thread bare. Kaurin reported a Norwegian who developed leprosy after wearing for a long time the coat of a deceased leper which he had bought.

Vaccination and the Transmission of Leprosy—Several decades ago there was much discussion on the alleged extensive spread of leprosy by arm-to-arm vaccination (Tebb) but careful inquiries showed there was no cause for serious alarm. The evidence both in India (V Carter) and in the West Indies negatived any appreciable transmission of the disease in this manner On the other hand, in 1885 Dr Arning in Hawaii found by the *examination of vaccine lymph from lepers that in cases of* extensive cutaneous leprosy in which skin apparently healthy contains bacilli, these are likewise to be detected in the lymph, but there were no bacilli to be found in the lymph taken from cases of pure lepra nervorum, in which no trace of the bacillus was to be found in the skin

Durodie also vaccinated a leper on apparently healthy skin and on an anæsthetic and unpigmented spot and found abundant lepra bacilli in the vesicle on the latter and a few in that on the former Bevan Rake and Thompson at the Almora leper asylum raised vaccine vesicles in 34 anæsthetic cases, 5 mixed cases and 1 nodular case they found acid fast bacilli in one of the anæsthetic cases and also in the only nodular case they examined. Hansen also admits the possibility of leprous infection through arm to-arm vaccination, although there was no evidence of its actually having happened in Norway

Arning who worked in Hawaii for some years, recorded his opinion that although the first general diffusion of leprosy over the islands was not due to vaccination, yet a very remarkable local accumulation of fresh leprosy cases took place in 1871–2

in a place called Lohaina, on the island of Mania. This happened about one year after a universal arm-to-arm vaccination which had been most carelessly performed. About 50 or 60 cases occurred suddenly in this locality which up to that time had been comparatively free from the disease He rightly adds that arm-to-arm vaccination should be prohibited in leprosy infected countries. A. C. Smith of Canada, states that a similar occurrence took place in Mexico Mouritz, who worked at Molokai in the eighties, records his opinion that vaccination undoubtedly spread the disease there and he estimated the infections so caused at 2 per cent of the whole number of cases

New light on this aspect of the subject has resulted from the observations of C E. Denny and R. Hopkins on the vaccination of 118 lepers and 105 healthy attendants in the United States National Leprosarium. Normal conditions were observed in the latter but most of the leprosy patients had abnormally severe reactions and in 11 of them alarming symptoms occurred in the form of fever pain great local swelling for one to three weeks and ulceration lasting one to two months. In addition, old nodules showed inflammatory changes and numerous new tubercles containing lepra bacilli appeared up to about the twelfth day and then rapidly subsided. Febrile ulnar neuritis also occurred and improvement following in some cases. In 1940 900 inmates of the Purulia leper home in India were vaccinated on account of a case of small-pox having occurred among the patients. In the two weeks before the vaccinations 11 cases of lepra reaction had been seen in the two weeks after the number of reactions was 41 and of a more severe type than usual. These interesting observations make it probable that the reported appearance of signs of leprosy after vaccination in Hawaii and elsewhere may have been due to similar reactions occurring in early unrecognized cases rather than to actual infections through vaccination of healthy persons from lepers

Among cases reported as having been due to vaccination are those of Hillis in British Guiana in a Portuguese brother and sister both vaccinated from a leprous Portuguese subject the brother aged 10 years, developed the disease after an incubation period of one and a half years and the sister later—a truly remarkable coincidence if not due to the vaccination as the rest of the family were healthy Further a case was reported by Professor Gairdner of Glasgow in which a doctor's son in the West Indies developed leprosy after being vaccinated from a native child belonging to a leprous family and later a European

child vaccinated from the doctor's child was found to have developed leprosy not many months later

Gavin Milroy reported that in the West Indies Creole families were always very anxious about leprosy in relation to vaccination and it was customary for them to obtain their lymph from the United States or from Europe.

Transmission of Leprosy by Inoculation through the Skin or Mucous Membrane—In the absence of certain knowledge of the mode of entry of the lepra bacillus into the body and in view of the fact that there is little or no evidence that it gains entry through either the lungs or the digestive canal it is necessary to consider carefully records in support of the commonly held view that the organism may find access through abrasions of the epithelial layer of the skin or the nasal mucous membrane. A study of the literature of the last few decades reveals a remarkable consensus of opinion that this is the most likely mode of entry of the lepra bacillus

Hansen and Looft in their book on leprosy state How leprosy is caught we do not know but we think it is probably by inoculation, and the nodular form must be more dangerous than the maculo-anæsthetic Kapon at the 1897 Berlin Congress said he thought inoculation by the skin to be the commonest mode of infection. Munro after quoting a number of cases indicating inoculation of the disease through wounds in the skin, concluded that inoculation is the chief, if not the only manner in which the disease is propagated, such propagation only taking place quickly when some special circumstances, as the person being wounded make inoculation easy and certain, while more or less prolonged or frequent contact is generally necessary to afford opportunities for inoculation in ordinary circumstances Vandyke Carter in 1867 was of the opinion that the casual inoculation of leprous matter is one actual means of spreading this fell complaint

Hillis wrote A further experience of ten years [after writing his book] has convinced me more firmly that leprosy is a communicable disease, most probably by inoculation Mouritz in Hawaii thought infection might take place by inoculation at broken surfaces, inhalation through mucous surfaces, or through punctures by insects. Dalziel reports infection of a child through being carried on a leper's back in Sokoto where scanty clothing is worn.

Infection through the Nasal Mucous Membrane has been much discussed since in 1897 Jeanselme showed that acid fast bacilli could frequently be found in the discharge from lesions of

the nasal mucous membrane of lepers Stricker soon after suggested that this was a common site of the initial lesion of the disease The frequency with which acid fast bacilli have been found in the nares of lepers by different observers is dealt with in the bacteriological section (see p 152) The percentage varied from 68 to 100 in typical nodular (37 in early cutaneous cases) and from 4 to 47 in nerve cases. It is thus a serious source of infection to others, although Stricker's view that nasal lesions are frequently primary in nature has been discounted by later observations. In the Culion settlement of the Philippines over 300 children living with their leper parents were examined for the earliest signs of the disease. No child was found to show a primary nasal infection and of 24 with primary skin lesions only 13 showed nasal lesions in addition These facts are greatly against Stricker's contention although it is possible that the primary lesion may sometimes occur in the nose

The Frequency of Nerve Leprosy of the Lower Extremities in Barefooted Races—This feature has been noted in Abyssinia where the disease is said to begin in the legs in no less than ten out of twelve cases among the barefooted inhabitants (Ehlers and Verdier) in Anglo-Egyptian Sudan (Tonkin) and Hawaii (Arning) Ehlers in Crete thought that the number of perforating ulcers in barefooted persons indicated inoculation through the feet, but injury to the anæsthetic tissues in the nerve form seems a more likely explanation. Muir however considered that early leprous lesions frequently occurred on the feet of bare-footed Indian races inhabiting rocky country but not nearly so often in those dwelling on alluvial soil free from stones (p 159)

Cases of Inoculation through Wounds of the Skin.—All the foregoing facts furnish strong presumptive evidence of inoculation being the commonest mode of transmission of the disease. On the other hand a number of attempts to infect healthy persons by experimentally inoculating them with material containing fresh lepra bacilli have completely failed, with the doubtful exception of Arning's case of a convict in Hawaii, who may have contracted his subsequently developing disease through contact with two infected relatives. This negative evidence loses much of its value on account of all the experiments having been carried out on adults who had passed the most susceptible age period, for none of the ten persons inoculated by Profeta were under 25 and most of them were from 31 to 47 years of age when the majority of persons are less susceptible to the disease It is significant

that in each of the four cases of reported infection through vaccination previously referred to (p. 86) the patients were children or adolescents in the most highly susceptible age period. Moreover a number of cases of suspected infection through inoculation are on record.

Forneé reported the infection of a European Sister of Mercy who inoculated her finger by a sewing needle during work in a leper asylum and the famous French surgeon, Larry that of an officer in whom the disease began in an amputation stump wound while in hospital in Egypt, where he had been in close association for six months with an officer suffering from leprosy Taché reported the case of a man who abraded his shoulder when carrying the coffin of a recently deceased ulcerated leper woman, liquid matter from which contaminated the wound and was not washed off until his return home Some months after he felt unwell and developed leprosy of which he subsequently died this case occurred in a temperate climate with very few cases so is of special significance. Hillebrand records a case in which a European child in Borneo became infected after thrusting a thorn into himself immediately after a leper boy had thrust it into himself. Solano relates a similar case in Colombia in which a boy of six years had a negro leper playmate aged eight years The latter introduced needles into nodules on his arms and legs and his master the younger boy took the same needles directly out of the negro boy and forced them into his own flesh, with the result that soon after he began to get febrile attacks and pains in his limbs and one year later he was covered with a typical nodular leprotic eruption. These last two cases have a special significance owing to their having occurred in children of a highly susceptible age and can hardly both have been coincidences.

Even more striking are two cases of inoculation of doctors while operating on lepers, as in both cases anæsthetic leprosy developed first at the very sites of the infected wounds, and it is scarcely conceivable that both should have been coincidences. In that reported by Dr Ehlers a Danish doctor wounded his finger during obstetrical operations on a leper negress. The wound took a long time to heal and he developed the disease commencing with severe pains in the wounded finger and going on to well marked anæsthetic leprosy In Hundadze s case a medical man inoculated a wound of his right finger in opening a leper's abscess. The wound healed normally but two months later the site of the wound became red and swollen, there was fever for three days and three weeks later red patches appeared with swelling of the cubital

gland of the same arm, which was at first taken for syphilis, but proved to be leprosy Such a rapid development beginning in the wounded finger left no doubt that the disease had been inoculated through the wound. Hatch recorded the case of a medical student who cut the tip of his left index finger and abraded his right hand at a post mortem on an advanced leper This was followed in a few days by nodular thickening and neuritis of the ulnar nerve and subsequently loss of sensation and muscular atrophy in the distribution of the ulnar nerve Vandyke Carter confirmed the diagnosis of leprosy The following recent instances confirm the inoculability of lepra infection Muir (1932) records the instance of a barber who shaved a leper daily and stropped his razor on his forearm a tuberculoid leprosy lesion appeared covering the strop area. The Union Health Report of South Africa for 1930 recorded that one of the medical officers became infected by pricking his finger through a rubber glove while operating on a leper Marchoux (1934) recorded that a surgeon in Paris was pricked by a needle during an operation for the removal of a leprosy nodule eight to ten years later when in a bad state of health, he developed an acid-fast bacillus-containing lesion on the injured finger

Lastly strong evidence of the infection of the human subject by inoculation of leprosy bacillus-containing material from another case has been brought forward by Lagoudaky (1936 and 1937) who has reported typical development of the disease in himself after inoculation into his own veins on three occasions of the blood of two Greek and one Egyptian leper respectively the first small lepromata appeared after forty days. Unfortunately treatment failed and he died in 1944.

Infection through the Alimentary Canal.—There is little or no clinical evidence of leprosy infection through ingestion of food for Hutchinson's fish theory has been discredited (p 61) In the case of rat lepra bacilli however Marchoux and Clorine (1938) have succeeded in transmitting Stephansky's organism to rats through both the buccal and the rectal mucosa.

INSECTS AND LEPROSY TRANSMISSION

In the immense amount of research on the relation of insects to disease carried out during the last few decades the leprosy problem has not been overlooked, although somewhat variable results have been obtained. The ways in which insects may possibly convey the lepra bacilli from the diseased to the healthy include (1) Mechanical carriage from an ulcerating leproma to a wound or

abrasion of a healthy person by the house fly (2) Such a burrowing insect as the *Acarus scabiei* may conceivably convey the lepra bacilli through the epithelium or afford means of access of the organisms to the connective tissues. (3) Blood-sucking insects may take up lepra bacilli from the leprous dermal tissues, convey them to the body surface of healthy persons and discharge them in their evacuations in the neighbourhood of minute lesions caused by their bites, thus allowing of the contaminative method of infection. Biting insects produce punctures of the skin which allows the entrance of lepra bacilli conveyed to the body surface during close association with infective cases This possibility has already been mentioned in the account of the close relationship that is found to exist between heat and moisture and high leprosy incidence (p 11)

Flies.—In 1910 Currie found many bacilli in the intestinal canal and in the fæces of flies fed on leprous ulcers and that they could convey immense numbers of lepra bacilli from such ulcers to the skin of healthy persons. In 1912 Leboeuf found 19 positive out of 36 flies caught in the room of four advanced lepers. In 1916 Marchoux found that flies conveyed the bacilli on their feet and bodies, but that the organisms soon died out of their intestines. Lambourn (1937) emphasized the role of non biting flies in carrying lepra bacilli from leprous ulcers to ordinary sores, cuts and abrasions He found lepra bacilli in *M sorbens* after feeding on leprous sores.

Acarus Scabiei has been found to be very frequently associated with leprosy in the Philippines where Heiser is said to have obtained a history of this parasitic infection in 50 per cent of leprosy cases Gomez in 1922 reported finding active or recent lesions of itch in one third of the children of lepers in the Culion settlement, where a number of them had become infected with leprosy but no data were available to show the frequency of itch in non leper communities

Lice were also investigated by Ehlers, Bourret, and Wirth in 1911 who found one slightly positive out of twenty *Pediculus capitis* fed on a leper Marchoux and Sorel (1912) found acid fast bacilli in lice fed on rats with rat leprosy but not in those fed on human leprosy cases. Joly in Madagascar found most of the inhabitants harboured *Pediculus pubis* and he suggested that their presence might favour infection during sexual intercourse.

Ticks.—In 1918 Rudolph in Brazil found lepra bacilli in the intestines of ticks up to thirteen days after feeding them on a nodule during a febrile period

Bugs have been repeatedly examined with more frequent positive results than in the case of other biting insects as shown in *Table XI*

E. C. Long readily found acid fast bacilli in bugs from non leper huts after feeding them on leprosy nodules, but controls were negative. He has also recorded the case of a man who slept in a hut from which a leper had recently been driven away was bitten there by bed bugs and developed leprosy within a year although he had never lived in a house with a leper

Table XI—RELATION OF BED-BUGS TO LEPROSY

OBSERVER	METHOD OF FEEDING	No.	POSITIVE	REMARKS
Goodhue (906)	Fed on nodule	—	—	*C. lenticularis* acid-fast bacilli found
Ehlers, Bourret, and Wirth (1911)	Ditto	53	3	
Sandes (9)	Ditto	75	20	
Lebœuf (1912)	Ditto From leper beds Fed during fever	44 41 —	5 1 3	Thinks insects only suck when blood vessel is punctured, so rarely infected
Skelton and Perham	From leper beds	175	0	Only a few acid-fast granules
D Thomson (1913)	Ditto Fed on lepers	33 105	0 0	
Johnston (1915)	Caught on lepers	3 5	4	
De Buen (1917)	Fed on lepers	25	2	
Total fed on lepers Total caught on, or in, beds of lepers		302 566	30 5	= 9·9 per cent = 0·88 per cent

Fleas were examined by Ehlers, Bourret and Wirth in 1911 only 4 of 108 3 7 per cent, gave positive results after being fed on nodules.

Mosquitoes were examined in 1903–4 by Noc, who claimed to have found 50 per cent of 150 positive after feeding on lepers but Currie in 1910 found no acid fast bacilli in 493 mosquitoes fed on nodular lepers. If we add to the last mentioned figure the observations of Sandes, Lebœuf and Ehlers and Bourret only 4 out of of 631 mosquitoes proved positive on examination after being fed or caught on lepers. Vedder (1928) found acid fast bacilli in

41 per cent of 100 *Aedes aegypti* mosquitoes immediately after feeding them on nodular or macular leprous lesions rich in lepra bacilli With permission of the Governor he also repeatedly fed such mosquitoes on two healthy long time volunteer prisoners with clean family histories just after feeding the insects on nodules and macules with negative results up to two years.

Cockroaches.—Lamborn has reported that cockroaches fed on leprous ulcers passed acid fast bacilli in their fæces up to the sixty-sixth day B Moiser (1914) reported having found acid fast oval bodies in the gut or fæces of 69 per cent of cockroaches caught in his leprosy hospital grounds or in kraals in the native reserve.

* * * * *

Lebœuf, as the result of a careful survey of the literature together with his own extensive observations on the role of insects in the transmission of leprosy concluded that house-flies may absorb abundance of lepra bacilli from infective ulcers, which neither multiply nor degenerate in their intestines so these insects may possibly play an important part in the propagation of leprosy by depositing living lepra bacilli in their excrement on mucous surfaces (such as the nasal orifice) and cutaneous wounds of healthy persons living in the immediate neighbourhood of lepers with open bacillus-discharging lesions. However the evidence regarding the powers of biting insects to transmit leprosy is not sufficient to incriminate them definitely as direct carriers of the infection from the diseased to the healthy

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Leeches also have been suggested as possible transmitters by van Breuseghem (1937) who found acid fast bacilli in those fed on infected lepers up to the twenty-second day and using a centrifuge up to the forty third day

Section III—PROPHYLAXIS

CHAPTER VII

HISTORY

The principle of the segregation of all cases of a communicable disease such as leprosy to prevent its spread by the infection of healthy neighbours is as simple in theory as it is difficult in practice. In the case of a highly contagious and dangerous disease such as small pox, with a combined incubation period and course of only a very few weeks it is comparatively simple to convince the average reasonable member of an educated community of the necessity for absolute and immediate isolation of every case as soon as discovered therefore the co-operation of the general public can be counted on in carrying out this essential measure. It is very different in the case of leprosy with an incubation or latent period of from a few months to several years and often with a slow and insidious onset, the early diagnosis of which requires considerable experience of the disease. Moreover the duration in the more rapid lepromatous cases averages eight to ten years and in mixed and neural cases nearer twenty years. This necessitates many years of incarceration of persons whose general health is usually but little affected for a considerable time and who hitherto have had little or no hope of amelioration of their sad condition. The disease is probably less infective than tuberculosis, though the serious facial disfigurement and the crippling loss of fingers and toes ultimately make the sufferers so repulsive that in all ages and in many parts of the world compulsion has been used to isolate them but usually only after they have already infected others while in the earlier stages of the disease Material benefit from the drastic measures enforced has rarely been obtained, so it is not surprising that they have only too frequently failed to stamp out, or even greatly to reduce, the incidence of the disease

Valuable lessons may therefore be learned from recorded attempts to enforce compulsory segregation in various countries

The drastic measures adopted against lepers in western Europe in the Middle Ages have already been described (p 4) The opinion was expressed that they were suited to control in some

degree a disease whose spread is usually dependent on prolonged close contact while residing in the same house as a leper and that leprosy subsided most rapidly in those parts of Europe where isolation was enforced, but remains to this day in some outlying European countries where it was little used (p 5) The barbarous methods of destroying and otherwise ill treating lepers by various African and Eastern races and their effects in lessening the prevalence of the disease have also been mentioned (p 54)

Leper Villages have long been used in many parts of Asia, Africa and Oceania for the isolation of leprosy cases, but they appear to have accomplished very little in reducing the disease in these backward countries In China patients are sometimes made to reside in leper villages but are allowed to go out begging In French Indo-China Kermorgant recorded that lepers in Laos were isolated on islands and in huts in the forest and after death their bodies were burnt instead of being buried. In Tonkin every important centre had its leper village surrounded by impenetrable bamboos and its entrance closed at night.

In Oceania very similar measures have been attempted by the French authorities with varying results In New Caledonia (p 37) the first attempts of the chiefs to segregate their lepers in five small villages failed to obtain real isolation and the measure was abandoned. In 1901 small leper villages to the number of 42 were established by the chiefs in New Caledonia with 568 cases, and in the neighbouring Loyalty Islands very similar measures were adopted in both instances they are reported to have failed in their purpose owing to the native chiefs not having sufficient authority to carry them out efficiently In this way 400,000 francs was spent uselessly in New Caledonia owing to vacillating policy and inefficient administration of these measures. After their abandonment and dispersal of the lepers the disease rapidly increased and spread to the European population, no less than thirty of whom were yearly infected. In the severely infected Marquesas Islands similar measures are reported to have been successful owing to the chiefs exercising more authority with the aid of careful watch by gendarmes (p 37)

Leper villages have for long been been used extensively for isolation purposes in Nigeria. Only lepers should be allowed to live in them, and every healthy child born in them should be sent at once to be brought up by healthy relatives in another village. But where there is not proper supervision the lepers mix with the surrounding inhabitants with injurious results. (See p 127 for an effective type of leper village.)

Home Isolation.—The segregation of lepers in their own homes under medical supervision has been tried in several countries with variable results in accordance with the type of the case and the efficiency or otherwise of the control. In South Africa Gregory reported that three lepers were allowed to be isolated in their own homes, but one of them infected his father mother and brother and of 22 authorized to live at home, 7 died and 5 were removed to the Robben Island asylum owing to failure to comply with the regulations, so he considered the method unreliable in that country In Romania the plan was given an extensive trial under a law making home isolation compulsory 245 lepers segregated in their families proved the point of origin of no less then 83 new infections between 1897 and 1903 and in the following five years 123 lepers thus isolated gave rise to 61 new cases the method thus proved a disastrous failure. In Madagascar and in Malta only closed uninfective cases were allowed to be isolated at their homes under close medical supervision, and in Norway a number of anæsthetic cases were successfully dealt with in the same way

A Special Leprosy Committee of the French Academy of Medicine reported in 1914 in favour of home segregation where good hygienic conditions and personal cleanliness could be ensured under close medical supervision—a most essential provision, which is rarely obtainable except in European countries. Dr Ehlers in the Danish West Indies laid down that for home segregation lepers must have separate rooms, feeding utensils, clothes, bedding linen, spittoons and washing accommodation Their old clothes and dressings should be burnt, their rooms disinfected before being used by others and their effects disinfected or burnt.

COMPULSORY SEGREGATION

From the earliest ages up to 1917 in default of any efficient treatment of leprosy even in its first stage, reliance has been mainly placed on the compulsory isolation of as many leprosy cases as possible in numerous attempts to stamp out the dreaded disease. Exclusive and drastic use of this method without humane modifications has for long brought opprobrium on modern medicine, for in no other chronic infective disease has immurement for life been enforced by legal enactments in countries all over the world at very high cost. Only success within a reasonable time in stamping out, or very greatly reducing the prevalence of leprosy would justify the extensive use of this method Unfortunately it is only in a few countries under exceptionally favourable

conditions that even a slow decrease of the disease has been obtained

DIFFICULTIES IN ENFORCING EFFICIENT ISOLATION

Impracticability of General Compulsory Segregation.—A glance at the data in *Table I* of the distribution and incidence of leprosy in the world indicates that probably not 3 per cent of cases are isolated at the present time when allowance is made for total numbers being several times as great as those known, as is proved by surveys in India and elsewhere. Nor is there the remotest chance of a sufficient proportion of the large numbers present in India, China and Africa ever being isolated under the compulsory system to allow of any material reduction being obtained by that drastic method.

Prohibitive Cost in Poor Countries.—The great effort of the American sanitary authorities from 1906 to stamp out leprosy from the Philippine Islands by means of general compulsory isolation at the Culion settlement is now admitted not to have effected any material reduction in the yearly quota of new infections, although many advanced cases were driven into hiding Yet no expense was spared, for it was reported in 1932 that since 1906 $20 000,000 (£4,000,000) had been expended at Culion and at treatment centres, and in 1933 Higgins recorded that nearly one-third of the total health appropriations of the islands was being devoted to leprosy control. Again, in Basutoland Strachan recorded in 1935 that the cost of the asylum (for lepers) has been a terrible drain on the resources of the territory In Brazil very liberal grants have been made for leprosy prophylaxis in 1939–40 alone the Federal appropriations for construction and improvement of the leprosy institutions amounted to 11 800,000 dollars They are planned to accommodate 24,888 patients.

In more advanced and wealthier countries even greater expenditure per case isolated has been incurred Thornton reported that the yearly expenditure on leprosy isolation in 1924 in the Union of South Africa was £154,000 but by 1934 it had been reduced (mainly through the release of uninfective cases) to £97,428, which was still nearly one fourth of the cost of the whole public health work. The conversion of the Louisiana leper settlement into the present Federal one of the United States in 1921 together with rebuilding and further expensive additions since made, cost several million dollars of capital expenditure, apart from the heavy annual cost of the large staff and upkeep In New South Wales for years the cost of isolating the small

number of lepers amounted to £200 per case per annum (Millard, 1926)

Difficulties in Ensuring Continuity of Policy.—A vacillating policy has frequently wrecked attempts to carry out prophylactic measures after their legal sanction. In French Guiana between 1823 and 1891 no less than twenty different administrative decisions on preventive measures were promulgated. Similar variations in policy have been reported in British Guiana by Hillis, in New Caledonia and the Loyalty Isles by Neal (p 37) and in Iceland (as shown in the chronological table on p 17) where leprosy increased after the leper hospitals were closed (Ehlers) Mouritz in his history of leprosy in Hawaii stated that the segregation question assumed the status of a political football, measures being frequently relaxed as unpopular before an election. An unexpected difficulty arose owing to the people regarding segregation as a pleasant way of living in idleness at Government expense they are reported to have deliberately attempted to get infected, even inoculating themselves from lepers for this purpose.

The rock on which compulsory isolation has hitherto always been wrecked is the fact that all the early and many of the most advanced cases inevitably hide, since immurement, often for life, without hope of recovery was all that could be offered them. For during the period before isolation they had time to infect contacts, especially those of their own households.

The Duration of the Disease before Discovery and Isolation. Strange to say the most convincing statement came from a confirmed supporter of compulsory isolation the late J A Mitchell, who in the Health Report of the South African Union for 1926 pointed out the long average period of 6½ to 8 years that had elapsed between the appearance of the first symptom of leprosy and the segregation of the patient, during most of which the disease may be infective. He concluded "The lesson of all this is obvious. Until we can devise some system or method of securing *early discovery* (italics in the original) and the early institution of precautions, we cannot hope effectively to limit the spread. *I am satisfied we shall never achieve this by methods of compulsion* (not italicized in original) we must secure the voluntary co-operation of the native people. In the Philippines Hasseltine (1922) recorded that over one-half the cases had had two years or more in which to infect others before they were segregated, and he pointed out that this hiding of cases has done much to reduce the power of segregation in the prevention of the disease. Again, in South Nigeria Ramsay (1928) found that the average duration

of the disease before segregation was 6·1 years. In French Equatorial Africa Robineau (1925) condemned attempts at forcible isolation as futile owing to the hiding of cases the best plan was to send successfully treated lepers in pairs through the villages to persuade other infected persons to come voluntarily to the leper villages to obtain the benefit of the improved treatment.

RESULTS OF SEGREGATION

We must now turn to the consideration of the most important attempts to carry out segregation measures in the past and see what lessons can be learned from them, beginning with those under the more favourable conditions presented by civilized and hygienically advanced European races in the north temperate zone

SEGREGATION IN THE NORTH TEMPERATE ZONE

In *Norway* prophylactic measures have been carried out more persistently and successfully than in any other country The early history of the disease has already been narrated (p 17) and showed 2833 cases in 1856 In 1857 a law was passed sanctioning the mild prophylactic measure of providing good hospital accommodation to induce the patients to reside there compulsion was only employed in the case of indigents and only 235 were at first isolated Careful records were kept and all newly discovered cases placed in the hospitals were entered in the year in which their symptoms first appeared so that in time the number of cases originating in each year were ascertained and compared with the number of unsegregated lepers remaining at large as foci of infection in each district. Hansen and Looft were later able to report If we examine in this way the numbers in the different districts, we find everywhere that decrease of the disease depends on the numbers isolated in the asylums. Where the isolation was insufficient or absent there was no decrease, *but the* numbers either increased or remained stationary where, on the contrary isolation was thorough, the decrease was invariable. This can only be explained in one way viz that isolation is the cause of the decrease, and isolation can only have effected improvement by removing from the homes of the people the sources of infection Further during the next five years the number of cases in those districts where isolation was good continued to sink where there was none, or it was insufficient the numbers either rose or remained stationary They also pointed out that the nodular cases are far more infective than the maculo-anæsthetic

type, and showed by figures that where segregation had not yet been carried out the increase of the disease was in proportion to the percentage of free nodular cases in a particular district.

By 1878 the value of the isolation of a considerable number of the lepers in decreasing the number of new infections had been so fully demonstrated that a law was passed giving limited powers of compulsory segregation. In 1885 a more efficient law was enacted under which any community could send their lepers to a hospital at public expense and local authorities had powers to remove lepers from their houses if reasonable conditions of isolation were not obtainable at home, including separate beds and eating arrangements under strict medical inspection. The more infective nodular cases were as much as possible sent to the isolation hospitals. During the first ten years after the commencement of isolation in 1856 the decrease was slight owing to the long incubation period and frequent slow development of the symptoms, but the diminution subsequently became greater as shown by the diagram (*Fig* 3) Further the greatest diminution of cases occurred just where evacuation into asylums was most complete. For example, in Sondfjord during the first fifteen years, 1856–70 from 31 4 to 38·2 per cent were segregated and the lepers remaining in the district fell during those three decades from 433 to 168 The proportion of the total lepers in the hospital gradually rose from 8·2 per cent in 1856 to 20 per cent in 1860 30 per cent in 1870 39 per cent in 1880 43 per cent in 1885, 52 2 per cent in 1895 and 63 per cent in 1910. There was a corresponding gradual decline in the foci of infection constituted by the cases still at large, but the infective power of the latter was diminished also by the measures taken to enforce home isolation The result is shown in the diagram, which conclusively demonstrates the effectiveness of the humane methods adopted in Norway

The Norway experience also brought out the important fact that, owing to the slow onset and progress of the disease only 1 out of 6 cases freshly found was of quite recent origin and the onset of no less than 5 out of 6 overlooked cases dated back three or more years This demonstrated the impossibility of discovering the great majority of leprosy cases in their early stages as long as their only prospect was isolation from their relatives with no appreciable hope of recovery Moreover with increasing success of the segregation policy the new cases became fewer and new infections decreased since the numbers remaining in their homes were continuously reduced but the growth of leprosy in proportion to the number of home-dwelling infectious lepers was not

diminished. Thus there had been no loss of virulence of the disease and the conditions for its extension in houses still occupied by lepers were in no way more unfavourable than formerly The decline was therefore essentially due to the gradual reduction of the number of contagious cases at large and capable of infecting the healthy population. Lie (1929) rightly laid stress on the fact

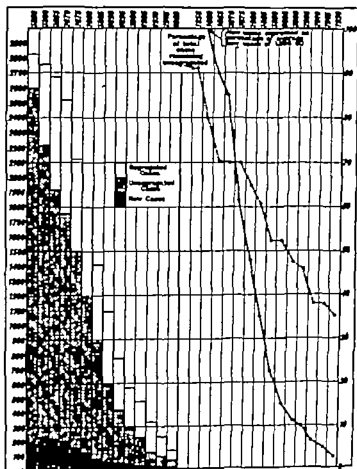


Fig. 3.—Chart illustrating the results of segregation in Norway

that the most infectious cases were isolated, and he also gave due weight to improvement in the economic and hygenic conditions in Norway during the eighty years of prophylactic measures.

In **Sweden,** very similar measures to those in Norway have been used with considerable success but only notification was compulsory The maximum number of cases of 103 in 1873 had fallen to 89 in 1907 to 37 by 1923 and to 20 in 1933 a reduction of 80 per cent on the numbers sixty years before, although the

disease was previously on the increase. Actual compulsory segregation was not used, but patients unwilling to go to the asylum opened at Jerfso in 1864 with room for 20 patients, were isolated at home under medical inspection By making the conditions of life at the asylum as endurable as may be, it has been found possible to bring the percentage of segregation to a very high point and thereby secure a rapid decrease of the disease especially in Helsingland" For the early prophylactic measures *see* p 18

Iceland. The leprosy hospitals which had been closed in 1848 were restored in 1897 after the visit of Dr Ehlers in 1894–5 Out of 226 known cases (3 per mille) 81 were admitted in the first year Total cases fell from 250 in 1896 to 98 or 1 1 per mille in 1907 67 in 1920 and 25 in 1932 This is a reduction of 90 per cent in thirty-six years, following the passage in 1897 of a humane law similar to that of Norway of 1885. This provided for compulsory notification together with home isolation under close supervision with the advice of the local doctors. If any of the precautions were neglected compulsory segregation might be enforced by the police, as was done in the case of all lepers in receipt of poor relief The children of lepers were brought up in other homes apart from their infected parents and the patients were not allowed to visit or to receive visitors. These precautions appear to have been very successful in practice, while interfering as little as possible with the liberty of the unfortunate patients In 1909 a law was passed that all the nodular cases must go to the asylum if there was room in it for them.

In **Sicily** infective cases are segregated at Messina. In **Italy** leprosy cases have been notifiable since 1923 and since 1928 their treatment has been the responsibility of the State

In **Canada** the slow decrease of the small outbreak in the New Brunswick Province following the use of segregation has already been described (p 37) In British Columbia a few Chinese immigrant lepers have been isolated on Dorsey Island near Victoria, or else repatriated. Thus in the large white dominion of Canada in the temperate zone the leprosy problem is not a serious one and is well under control.

SEGREGATION IN SUBTROPICAL COUNTRIES

In **Australia** compulsory segregation has been enforced for several decades. Chinese and Oceanic Island immigrants are isolated until they can be repatriated, and Europeans are detained and treated until they have been bacteriologically free for eighteen months.

Queensland. Ever since 1907 compulsory segregation of all discovered leprosy cases has been enforced at the Peel Island lazaret, where the conditions have recently been made as comfortable as the circumstances permit. The number was 71 in 1910 and in the six years to 1935 they averaged 60. The slight decline was due to the discharge of 14 patients after being bacteriologically negative for eighteen months. There is thus little evidence that the disease has decreased materially as the result of three decades of compulsory isolation. The reports do not record regular examinations of contacts to discover early cases.

New South Wales has had compulsory segregation laws since 1883 During the period between this and 1936 191 cases were found, including 58 Chinese, 33 of whom had been repatriated and another 20 died The number isolated remained at about 20 from 1908 to 1936 Here again no diminution has resulted from these decades of segregation in spite of a number of repatriations to China.

The Union of South Africa with a large white and coloured population has a serious leper problem. The history has already been given (p 26) and is further illustrated by the figures in *Table XII* which shows that ever since leprosy was found to be prevalent in Cape Colony in 1817 the disease steadily increased over a period of one hundred years, as long as rigid but inefficient segregation measures were carried out.

In 1885 a South African Leprosy Commission reported a steady increase in the disease among both coloured and white population, and stated that with proper measures its further progress could be arrested As a result a Leprosy Repression Act was passed in 1885 but was not promulgated and put into force until 1892 after another committee in 1889 had found a further increase of the disease and had estimated the number in Cape Colony at 600 *Table XII* shows the great increase in the numbers isolated under the Act from a yearly average of 43 in 1887–91 to 294 in 1892–3 and 1007 in 1894–1905 The total number segregated rose from 625 in 1891 to 2790, 2·21 per mille in 1907 showing the ineffectiveness of the isolation policy in Cape Colony before the formation of the Union of South Africa.

Compulsory Segregation in the Union of South Africa.—Subsequent to the formation of the Union in 1910 the data refer to the whole area and great efforts have been made to stamp out leprosy by compulsory segregation measures which are of special interest. The work was for some years handicapped by lack of enough room

in the various institutions to accommodate the discovered and registered cases. The segregated increased steadily from 1491 in 1905 to 2375 in 1918 Between 1900 and 1917 only 275 patients were discharged from the six leper institutions of South Africa In 1924 Sheldon recorded that the Health Department placed the total number of cases at 5170 equal to a rate of 0 74 per mille for the Dominion, a steady increase in spite of all efforts to enforce segregation. It was also recognized that this failure was essentially due to hiding of cases since the average duration of their disease on discovery and isolation was 6½ years or more.

Table XII—Leprosy in South Africa

Cape Colony Lepers

Robben Island Asylum Cases				*Total Cases*				
Years	Average Yearly Admissions	Average Daily Cases	Yearly Total	Year	Asylum Cases	Outside Cases	Total	Per Mille
1845–52	21·0	—	—	—	—	—	—	—
1853–6	19·4	54·0	—	—	—	—	—	—
1861–7	21·8	—	80·7	—	—	—	—	—
1872–86	30·3	—	98·7	—	—	—	—	—
1887–9	43·0	1·0	136·0	1891	505	20	625	0·41
1892–93	294·0	561·0	—	1895	531	646	1177	1·02
1894–905	100·7	536·5	—	1904	—	—	2282	1 81
—	—	—	—	1907	—	—	2790	2·21

Modification of Segregation Policy to Release all Uninfective and Arrested Cases—In 1922 the Health Department of the Union took over control of leprosy prophylaxis and their activity is shown by the increase in the number of natives isolated in that year as shown in *Fig* 4. More important was the recognition that a large number of chronic nerve cases are uninfective, as had been urged by a South African medical man, Impey as early as 1895 and later by Rogers This led to the bacteriological examination of the 2501 segregated cases and the release of in 1923 503 out of 693 negative cases as arrested the number of these soon after increased to one third of the total isolated cases, thus allowing room for the admission of many infective cases which could not previously be accommodated. Further the value of the improved treatment in early cases was now beginning to be recognized in South Africa, with the result that in the three years up to 1925 862 patients were discharged as uninfective against 275 in the eighteen years to 1917 The public thus learned for the first time

that the leprosy institutions were no longer lifelong prisons, but were becoming hospitals and sanatoria for the efficient treat ment of the patients with greater prospect of release on recovery

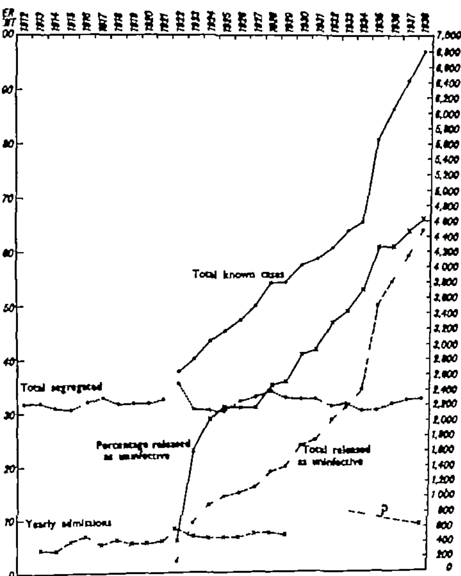


Fig 4.—Segregation of leprosy patients in the Union of South Africa. (For explanation, see text.)

the earlier the patients came forward Dr Mitchell's
annual report for 1926 reveals a of h with
the recognition of the value of the
adoption of the plan of ons
over a period of five years or in

an early and amenable stage. Without this he was now convinced the compulsory system would never succeed, but with it the spread of leprosy in the Union would very soon be checked and reduced

The available South African data charted in *Fig* 4 enable the subsequent progress to be gauged The upper continued line shows a steady increase in the total number of known cases of leprosy in the Union This is essentially due to improved survey methods, and especially to the greatly increased number of voluntary admissions in early stages to obtain the benefits of treatment, and not to any actual increase of cases in the country In 1944 A. R Davison reported that the average duration of the disease prior to admission used to be about 9 years to-day it is nearer 2 years. The broken line shows the total number of cases released as uninfective which had increased by 1938 to 4502 66 per cent of the known cases. In that year 1764 of these were still under surveillance in accordance with the rule that recovered cases released after being negative bacteriologically for eighteen months are re-examined at intervals for several years to detect relapses The remaining 2738 have been released from such surveillance as uninfective and not likely to become a danger to others The dotted line shows the yearly number of cases under care in the five or six State leper Institutions These are now of the colony type with land to cultivate, in place of the prison like Robben Island one at Cape Town which was closed in 1931 The number of yearly admissions increased in 1930 to 1933 with the increasing number of cases discharged as uninfective, but later figures are not given in the reports except in 1938 The number of relapsed cases readmitted varied from 2 in 1924 to 37 in 1931 so formed only a small proportion of those released, but some may have been overlooked The proportion of the total cases released as arrested or uninfective is now nearly double the number of isolated infective ones so a decline in the yearly number of new infections requiring isolation may be expected In 1944 F A. Thornton reported that during the previous ten years 27 3 per cent of all admissions to the Emjanyana, Transkei Institution had been discharged. The new policy of releasing uninfective cases has also led to decrease in the annual cost of the compulsory measures from £204,000 before the Health Department took over control (1922) to £154,000 in 1924 and £97,428 in 1936 but the estimated expenditure in 1939 was £125 596 or £54 per case

In the Union of South Africa, where there is a universal segregation law it is only in the Pretoria institution in the industrial area that compulsion is found to be necessary In the other four

institutions which cater for the less sophisticated tribesmen, patients are usually persuaded to enter and remain voluntarily and the law seldom has to be enforced

In the **United States of America** it has already been shown (p. 39) that the main incidence of leprosy is in the hot Southern States bordering on the Gulf of Mexico and that a number of imported Scandinavian cases in the North-Central States tended to die out under the favourable hygienic and climatic conditions pertaining there. In 1894 a leprosy home was opened in Louisiana and had about 40 admissions in the first six years all but 10 coming voluntarily Compulsory powers were obtained, but the law was not enforced because of political colour in its execution aided by apathy of the people and the doctors and inactivity of the Board In 1902 the home was overcrowded and tumbling down but was largely rebuilt with State funds by 1904.

In 1916 a committee on a Senate bill collected valuable data and reported in favour of compulsory segregation. The Senate voted a sum towards establishing a national leprosarium, but difficulties over a site delayed its opening until 1922 as an extension of the old Louisiana settlement at Carville on the Mississippi with 4000 acres of ground, to which 174 patients were admitted in 1923 This has since been developed at great cost into the best equipped hospital and colony in the world which should in time help to effect the desired reduction of the disease in the United States

SEGREGATION IN TROPICAL COUNTRIES

In **Hawaii** or the **Sandwich Islands** prolonged efforts have been made under very difficult conditions and with little financial means to combat the epidemic of leprosy which broke out in the middle of last century as already described (p 36) In 1863 Hillebrand reported the disease to be rapidly spreading and in January 1865 a law was passed providing a hospital at Kalihi, near Honolulu for the examination and treatment of 50 early cases. Confirmed cases were segregated on Molokai, an isolated peninsula measuring 2½ by 3 miles and bounded landward by a 2000-ft. cliff. Very few of the lepers surrendered voluntarily and many were hidden by their relatives as the people did not fear the disease As a rule only advanced cases, which had become a nuisance to their friends were isolated and the average annual total mortality in the settlement during the first two decades was 21 per cent, the conditions being very bad, although they were somewhat improved after Father Damien's arrival in 1873.

Divorce from a leper was legalised in 1868 In 1884 the Board of Health recorded that 10 per cent of the whole revenue of the islands was spent on medical and sanitary measures, two-fifths of which was expended on the leper settlement, at least 20 per mille of the population being then affected, although in 1886 only 7 8 per mille were isolated—a little over one-third. Over 90 per cent of the segregated cases were of several years' standing when first discovered, showing that the extensive hiding of cases was still prevalent. At that time the Board considered that there was every hope that leprosy was declining but this opinion proved to be premature, as will be seen from a reference to the chart (*Fig* 5) The steady yearly decline in the numbers isolated *between 1878 and 1886 was solely due to the small numbers sent* to the settlement, which reached the minimum of 43 in the latter year Renewed efforts raised the figure two years later to the record number of 571 admissions. A steady fall in the numbers of lepers commenced in 1891 which has continued ever since, and *the rate per mille fell from 13 5 in 1890 to 2 16 in 1919, only* one-sixth, as shown in the chart, but in 1925 it was 3 86 (Araujo) The great variations in the yearly admissions between 1865 and 1888 are explained by the statement of Mouritz in his history of the struggle against leprosy in Hawaii that the efforts to stamp *out leprosy by segregation have taken on the status of a political* football.

In 1922 Hasseltine reported that many leprosy patients had surrendered voluntarily for the sake of obtaining the improved treatment, and since a number of recovered cases had been paroled there had been a material rise in the proportion of the admissions during the first year or two of the disease. In 1934 Wayson and Rhea noted a steady decrease in the admission rates from 3·6 per mille in 1890–1900 to 1·3 per mille in 1920–30 this they attributed to general biological and environmental influences rather than as a result of specific control measures"

In 1906 in the **Philippines** the American sanitary authorities, under Dr Victor G Heiser founded an island leper settlement at Culion under great difficulties they induced many of the lepers to go there voluntarily but used compulsory powers to isolate all the others they could find

Fig 6 is based on data kindly supplied through Dr H W Wade. Above is shown the annual and the three-yearly average admissions to Culion and below the total cases at Culion in each year by the continued line and the three yearly numbers corrected to the average mortality in the broken line. *The increased admissions*

in 1922 following a decline, were due to the attractions of the improved treatment. The later portion of the lower curve shows a flattening out of the rise in the total numbers at Culion

The progress of this important trial of compulsory isolation in a tropical country may be gathered from papers by the expert medical staff of the Philippines In an article on the evolution of the campaign in the Philippines Dr Wade in 1930 stated When all the known lepers were transferred to Culion it was expected that the incidence of leprosy would decline rapidly

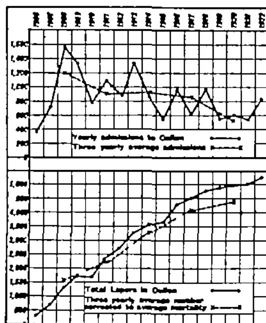


Fig 6.—Chart illustrating the result of segregation in the Philippines.

thereafter an expectation that did not materialize. This he attributed to the large number of hidden or undetected lepers so that the average number of cases segregated annually did not materially decline during the first fifteen years He went on to say that a new era commenced in 1921 with the advent of a comparatively successful treatment, which altered the whole situation and made it possible to modify the campaign by opening regional treatment centres. Hundreds of early cases voluntarily attended local clinics as out patients, and only the more infectious cases were sent to Culion In 1935 a report of the Philippine Leprosy Commission to the Governor-General stated that it could not be shown statistically whether the disease had decreased or

not during the twenty-nine years compulsory segregation had been in force, but it was thought now to be decreasing because, although the number of new cases had remained constant at about 1000 yearly during the last five years the majority of them had been early ones. Seven successful regional treatment centres had 1592 patients. Follow-up treatment of the numerous relapses among paroled cases was needed In 1936 Rodrigues in a review of compulsory segregation pointed out that little success had been obtained except in Norway he considered that the recent Philippine policy of trying to cure patients in the earliest stage before isolation is necessary is the more logical and economic one. Hasselmann in 1933 pointed out that this method is more on the lines of the principles and aims advocated in India.

The Philippine trial once more emphasizes the enormous difficulties encountered in trying to stamp out leprosy by segregation alone in backward tropical countries and the necessity of supplementing that measure by the attractive powers of the improved treatment now available.

In **New Caledonia** up to 1924 there was only nominal and ineffective isolation of leprosy patients in 64 segregation villages with no proper supervision or treatment. By 1936 there were ten agricultural colonies with good hygiene and a dispensary to supply regular treatment for the contagious cases. The closed uninfective ones are free and are treated in their own villages and examined every three months for infectivity European patients have their own sanatorium and in 1939 the outlook was reported to be much more hopeful.

In **Fiji** compulsory segregation has been in force only since 1911 (p 35) The Makogai settlement is on an island measuring 1½ by 2½ miles, with five leper villages, one for each race, under leper headmen and a hospital for the helpless All cases are certified by two European medical men before removal unless their friends can isolate efficiently at home. Cases remaining bacteriologically free for two years can be discharged and are inspected every three months and returned if they relapse. The numbers isolated have gradually increased from 40 in 1911 to 351 in 1920 and 691 in 1943 (Austin) the apparent increase is due to the settlement admitting patients from the Solomon, Cook and other island groups, and possibly to more patients coming forward voluntarily to obtain the benefits of the modern treatment. The sexes are kept separate and agricultural work and amusements are provided. Their friends are brought to see them twice a year in a Government vessel but are not allowed to enter

the lepers houses Up-to-date medical treatment is also provided (Hall)

In the **Penrhyn Islands** leprosy appeared in 1883 but partial segregation lessened the spread and it has not increased in recent years. Only 27 cases and 20 deaths occurred in seventeen years Cases suspected to be infectious are segregated (May)

In the **Dutch East Indian Islands** we have already seen (p 52) that leprosy is reported to have increased after the closure of fourteen leper hospitals in 1868 following the report of the Royal College of Physicians of London that the disease is non-contagious. Later isolated efforts on a small scale to enforce compulsory isolation met with little success. Gradually modern methods have been adopted with the recognition of the great importance of protecting children from infection Sitanala (1936) recorded that the Dutch Government in 1897 accepted the finding of the First International Leprosy Conference of that year in favour of compulsory isolation, but it was never legally enforced In 1925 a bill to make it possible was rejected In 1930–1 a policy was adopted of relaxing compulsory isolation in favour of early out patient and other treatment

In 1930 Sitanala reported that 47 leprosaria accommodated 4,955 leprosy cases five of them aimed at combating the disease the remaining 42 were of a philanthropic character

In the **Danish West Indies** in 1908 Dr E. Ehlers obtained the enactment of laws for notification of all lepers, the formation of a colony for them and the segregation of beggars, vagabonds and those certified after medical inspection to be a danger to others. Other measures were home segregation of some cases, with separate cooking and table service under inspection leper immigrants to be refused admission and returned at the cost of the ship bringing them and most important of all, the removal of all healthy children under fifteen years of age from any house having a leprosy case in it.

In **India** the Leprosy Commission of 1889 (p 64) was followed by the passage of an Act in 1890 authorizing pauper lepers only to be compulsorily isolated but as it was enforced only to a very limited extent in the Presidency and other large cities, and only in the case of patients showing ulcerated lesions, it remains practically a dead letter It is generally agreed that compulsory isolation is quite impracticable on a large scale in India, if only on account of the prohibitive cost of dealing with the immense numbers Private and Government enterprise had resulted in the provision of a number of leper asylums which in 1921 accommodated 8890

patients, the great majority of whom were in those of the Mission to Lepers (Oldrieve) and by 1932 the total was about 10,000, many of whom were little infective chronic nerve cases. In 1941 a committee of the Central Advisory Board of Health, India, reported on the position of leprosy prophylaxis in India. The census figure of 150 000 is considered to be only about one-eighth of the actual number if early cases are included. The infective cases are estimated at approximately 250 000 only about 14,000 are accommodated in leprosy institutions including a large number (probably about one third of the total in the cases under the Mission to Lepers) of uninfective crippled nerve cases The Committee recommended the establishment of at least one agricultural colony for infective cases in each province of India this measure had been advised by L Rogers at a leprosy conference in Calcutta in 1920 Yet the only new one as yet is near Madras. Good work is being done in the treatment of early cases at numerous out patient clinics, but they will not alone solve the problem. Home isolation of cases where feasible, is an important measure for protecting children against contact infection. In-patients cost at least 12 rupees per month (£10 to £11 a year) The voluntary system of isolation should continue to be relied on. The Committee also advised the removal of the Leprosy Research Department of the Calcutta School of Tropical Medicine to a large agricultural colony since only out patients are available there. A more comprehensive Leprosy Act is also advised

Ceylon passed a leper ordinance in 1901 but insufficient accommodation prevented its efficient enforcement. An additional asylum for the eastern districts was opened in 1921 but no appreciable decrease has yet been obtained, as shown by the following census figures 1902 560 lepers known, or 0·15 per mille in 1921 577 cases, 0·13 per mille In 1931 Cochrane advised making segregation less rigid. In 1932 compulsory segregation gave place to the modern methods of surveys, propaganda, training medical men regarding leprosy the establishment of out patient clinics for treatment of uninfective cases, and repeated examination of all contacts with known cases. The 557 cases known in 1921 was raised by 1939 to 3648, 0·7 per mille, mainly through the discovery of 2548 by surveys 1 031 infective cases are isolated. Now that many cases are found in early stages of the disease modern treatment is restoring the health of the majority of them. The number of new cases is already declining

In the **Malay States** a leprosy prevention ordinance was passed in 1893 and compulsory isolation was rigidly enforced,

with release only in the rare event of a patient being certified as cured In 1929 the Principal Medical Officer approved of the policy of attracting lepers to come early for treatment at special clinics without being arrested and confined Smart (1933) reported that the confidence of the patients was being won by these modern methods with an amazing change for the better in the whole outlook. Many immigrant Chinese and Hindu cases have been repatriated so it is not possible to judge as to the results of the compulsory measures in reducing the incidence of leprosy in Malaya.

In **Tropical Africa** compulsory isolation is usually so obviously impracticable on a large scale that it has rarely been attempted Robineau in **French West Africa** reported that an attempt to collect the leprosy patients forcibly with the aid of soldiers completely failed owing to their all being hidden and he condemned it as futile. On the other hand, the plan of sending fairly early successfully treated lepers in pairs through the villages enabled numbers to be persuaded to come voluntarily to the camps for treatment (Robineau, 1924) In the same area Joseph (1933) reported failure of compulsion and success of modern methods, and Marchoux (1934) stated that anti leprosy campaigns that had long been carried on in the French colonies based on internment of cases had not given the expected results. As early as 1924 a ministerial circular on leprosy in French Colonies recommended the abandonment of the medieval principle of compulsory segregation, the provision of colonies for infective cases and treatment of uninfective ones at their homes. In 1931 a consultative commission including Professors Jeanselme and Marchoux, drew up a programme of measures. In **French Congo** territory Berny (1933) reported that any attempt at compulsion fails completely through wholesale hiding of the lepers. In 1939 Dellnotte recorded detailed statistics, a summary of which showed 104,000 known and 170 000 estimated cases in the various French colonies In the absence of surveys this is likely to be much below the true number

In **Madagascar** the French authorities for long enforced compulsory isolation under a code of 1881 with the help of missionary bodies (Jeanselme) The measures included the separation at birth of infants from their leper parents in the six official colonies with care of them for five years No material reduction of the disease had been obtained, for the interned cases numbered 3299 in 1904 and 3005 in 1932

In **Tanganyika** the Germans in 1912 had isolated 3800 cases in forty-seven villages. Without adequate supervision there is no

apparent reduction of the disease. In 1931 Janet Murray found that a leprosy clinic attracted leprosy patients then, although previously they never showed themselves for fear of compulsory segregation

In the **Belgian Congo** van Campenhout (1934) advised modern methods of attracting cases to come voluntarily to hospitals, dispensaries and colonies In 1939 a commission reported that in a part of this colony 60 963 cases had been found and 14,983 were isolated in leprosaria, nearly all of the agricultural colony type, but 3 000 were in segregation villages or camps. Treatment is provided and additional colonies are recommended.

British West Indies and **Guiana.**—The incidence of leprosy in this area has been dealt with on pp 43 45 A study of the data up to 1921 led Rogers in the first edition of this work to regard them as affording evidence of the value of compulsory isolation. Unfortunately later data and information have not confirmed that impression, which was based on an apparent decline in the number of known cases in Jamaica and British Guiana, where the segregation laws had been longest on the statute book. It transpired that much of the apparent fall was due to repatriation of affected immigrants to India.

British Guiana.—This was the first British colony on the advice of the British Leprosy Relief Association, to modify its compulsory segregation law by permitting early uninfective cases to be treated as out patients at special dispensaries in the worst affected areas, which are now nine in number Surveys led to the discovery of many new cases the more infective of which were admitted to the Mahaica settlement, mostly voluntarily The known number of cases rapidly rose and regular treatment resulted in 71 4 per cent of those receiving a full course becoming arrested cases and uninfective, against only 16·7 per cent arrested of those who received less than 60 per cent of the prescribed course striking testimony to the value of the modern treatment by injection of soluble preparations of chaulmoogra preparations. Muir however found in 1943 that the follow-up of discharged cases was inadequate and that there were many relapses among them, while infective cases were living at home without sufficient supervision.

In **Trinidad** compulsory isolation was introduced in 1915. In 1924 the greatly improved island settlement at Chacachacare was constructed at heavy cost with separate areas for males and females in place of the prison like town asylum of Cocorita dating from 1845 In 1940–41 a survey of all the schools showed a fairly

high incidence chiefly of early neural cases among children rising to as much as 3 per cent in one school These cases are now treated at some 7 clinics. Almost all the doctors in the island have received special training in leprosy and earlier infective cases are now admitted to the leprosarium chiefly at their own desire.

West Indian Islands.—As late as 1939 repeated visits of inspection and reports on the leprosy problem in British West Indian Islands by B E L.R.A officers failed to result in the adoption of modern methods of prophylaxis except in British Guiana This is essentially due to the poverty of these small colonies, but it is anticipated that the recently constituted Colonial Development Fund will result in the recommendations in reports of Dr Muir being carried out under the promising conditions afforded by such small isolated communities for the successful adoption of modern methods. The urgent need for this is evident from the fact that in 1944 in Jamaica Muir found 47 highly susceptible children living in close contact with 17 unsegregated very infective lepromatous cases. A whole-time leprosy expert is required for this large island As the result of Muir's visits during 1940–44 the West Indian Islands are gradually adopting modern prophylactic measures.

In **South America** compulsory isolation has long been used in extensive areas with the following results.

In **Colombia** the largest segregation colony was founded during the eighteenth century at Agua de Dios in a healthy elevated area. Another is situated at Contratacion. The former had 3483 inmates in 1908 and in 1929 three colonies accommodated a total of 7 086 cases according to Jeanselme. In 1940 Araujo reported the number to have risen to 8200 so the number appears to be still on the increase after about a century and a half of compulsory segregation Nor is this surprising in view of the fact that in 1938 Araujo found no less than 2341 children under five years of age living with their leper parents in the two leper colonies above mentioned clearly the most certain method of maintaining the number of new infections. A beginning had however been made in providing separate accommodation for some 600 children of leper parents. No attempt at surveys or arrangements for treatment of early cases at out patient clinics appear to have been made as yet nor are contacts of known infectious cases examined for the early signs of infection

In **French Guiana** an island leper asylum was in existence in 1777 and Leger (1934) stated that two centuries of compulsory segregation had failed to prevent even a slow increase of leprosy

itill larger proportion when parents suffer from the severe romatous type

| A large proportion of infections arise through close contact h advanced lepromatous cases these most require isolation, was done mainly under a voluntary system, in the successful rway campaign

|- Most advanced crippled cases, the popular dread of which is te unjustified are little if at all infective. Yet in some countries y formed one third or more of the total cases isolated for life the old type prison-like leper asylums, even in some instances ler the compulsory system (*see* SOUTH AFRICA, p 105)

; Treatment to be effective must be begun early and continued two or more years, with follow up periodical examinations to ect and treat relapses

i The most effective way to reduce the incidence of leprosy idly is to trace and examine every few months over a period of at st five years—that is, over the usual period between exposure to ection and development of the first symptoms—every person o has been in close contact with any known infective leper large proportion of the infections from each case so discovered the earliest stage can be cleared up and others who develop : lepromatous type can be isolated early If this is repeated r a second period of five years few infective cases will remain the area dealt with for within one decade most of the highly ective advanced cases will have died or passed into a little-ective nerve form. This plan has for long been advocated by gers and has now been carried out with a considerable degree success on a small scale in Nauru Island (p 137) and on a ger one in the Sudan (p 128) and adopted in several other intries It is, however difficult to carry out in a floating pulation in an industrial area, and it may require a large staff

THE ROLE OF COMPULSORY ISOLATION IN PRESENT DAY PROPHYLAXIS

As long as we had no treatment of material value there was ne excuse for resource to the crudities of the Middle Ages long segregation of lepers. That excuse vanished when it came possible to clear up or remove the infectivity of a large oportion of early cases of the disease by the injection of soluble oducts of the chaulmoogra oils, as shown by Rogers in Calcutta 1915 to 1917 and confirmed and extended by Dean and llmann in Hawaii in 1919. No one would now advocate the

earlier used enforcement of isolation by hunting down hiding lepers like wild beasts and shooting those resisting arrest (Rodrigues 1936) even if such measures had not failed materially to reduce the disease in every tropical country where they have for long been used. On the other hand the immediate and complete repeal of all compulsory powers is not advocated but only their modification to ensure that they do not continue to result in the hiding of many of the early cases until it is too late for them to obtain the full benefits of modern treatment when still most amenable to it. The retention for a time at least of legal powers already in force may be required for the restraint of especially dangerous patients who are not amenable to reason

Special circumstances may indeed justify the use of a certain amount of compulsion in a new area for the purpose of ensuring efficient isolation and large-scale treatment, as in the cases of the Southern Sudan (p 128) and at Nauru Island (p 137)

The Degree of Compulsion Necessary or Advisable varies under different circumstances —

1 In poor countries where there is high endemicity and institutional accommodation cannot on account of cost be provided for more than a small fraction, properly run leprosaria will always attract voluntary patients to more than their full capacity compulsion to bring in more patients is therefore ruled out. In such countries, however the tribal or other similar authority if it is functioning efficiently can be used to bring about, either by compulsion or moral suasion, the isolation of all infectious cases outside the village or township In doing this however there are two vital requirements the local authority must provide land and other necessary help for those whom they are separating from their community and the public health authorities must supply adequate efficient supervision In proportion as the tribal or similar local authority is inefficient, the above method will not function satisfactorily and the control of leprosy may be delayed until efficiency can be built up

2 In small islands or other small communities with very little communication with the outside, it is possible to make an exhaustive survey and control the disease by the methods mentioned above in a few years time with a minimum of compulsion. But control is more difficult in highly industrialized areas such as those in the Rand in S Africa, and Trinidad in the West Indies, where there is a constantly shifting poorly-educated population with little or no social cohesion. In such places a greater degree of compulsion must be applied to control a disease like leprosy

3 In wealthy countries, where the majority of the people a educated and there is an efficient public health personnel, th elimination of leprosy by the system used in Norway can easily be accomplished The chief stumbling-blocks in doing this have often been a vacillating policy and political intrigue.

Modification of Compulsory Segregation to allow Early Cases to be Treated at Clinics as Out-patients.—To obviate the grave defect of compulsory isolation in leading to hiding of the early cases most amenable to treatment the British Guiana Government modified their law to allow early cases to be treated at clinics without isolation. This was done at the suggestion of the British Empire Leprosy Relief Association, who provided funds for supplying two clinics in areas from which most admissions had been received, with the gratifying result that many new cases came forward for out patient treatment and a number of the more infectious ones voluntarily entered the Mahica leper settlement with most beneficial results (Rose, 1934) Dutch Guiana has followed this example, compulsory segregation being retained for cases not complying with the regulations (Lampe, 1932) In the Philippine Islands, in addition to regional treatment centres near large towns, skin clinics have been opened for the out patient treatment of early uninfective cases without isolation. Wherever this plan has been adopted many early cases have come voluntarily under control which were previously hidden until too late to benefit materially from treatment. A further great advantage has ensued in that these earlier cases lose their symptoms and infectivity much more frequently than formerly and can be released under parole. Thus, with a follow-up system to keep a watch for relapses when possible, has done much towards bringing home to the people that the isolation policy no longer means life long imprisonment, and not rarely results in recovery at least in a clinical sense with restoration to their families and very great reduction in the dread of leprosy institutions The greatly increased number of voluntary isolations for the sake of treatment thus brought about has been stressed in the Philippines, for example, by Wade, Rodrigues and others (1932)

A **Medical Board** of two or three expert leprologists may be required in countries adopting the above modified compulsory system who will decide the cases that should be isolated and those to be treated at clinics They will also report on the fitness of successfully treated cases to be released from isolation under parole.

Compulsory Notification is a corollary to compulsory isolation but its value in backward tropical countries in such an easily

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Compulsory Notification is a corollary to compulsory isolation, but its value in backward tropical countries in such an easily

hidden disease is very doubtful South Africa formerly tried to enforce it with the result of causing early cases to be hidden and in more than one instance known to the writer an unfortunate patient has come all the way to England for treatment to avoid notification with consequent segregation. The Paris Academy of Medicine in 1914 advised compulsion and the Danish Government on the advice of Dr Ehlers carried it out in Iceland and in the Danish West Indian Islands before their transfer to America so it may be of value in countries with advanced medical and sanitary organizations in areas permitting out-patient or home treatment of early cases, provided it does not encourage hiding of cases

Compulsory Home Isolation.—We have already seen (p 97) that in Romania and in South Africa this measure failed to prevent infections although it was more useful in Norway in the case of the less infective nerve cases. It is not as a rule to be advised except where a highly organized public health organization is available to control its application In India, however as the result of village surveys and an educational campaign, it has sometimes been possible to get highly infective cases voluntarily isolated either in huts outside a village or in a separate room opening only outside the family compound, so as to prevent contact of the patient with healthy relatives especially children.

In Madagascar and Malta only patients without open lesions—that term to include all cases with discharge of lepra bacilli from the nose—are permitted to reside in their homes. The regulations should provide for medical inspections not less than once in three months to see that the rules are strictly complied with, in default of which the patients should be sent to leprosy institutions. At the same time all residents in the patient's house should be inspected for early signs of the disease to enable them to be dealt with from the commencement of the attack. In accordance with the excellent laws of Iceland the Danish West Indies and Memel, the home-isolated patient should have a separate room separate cooking and table service and his bedding and clothing should be washed separately after disinfection. He should neither receive visitors nor visit others and his room and effects should be disinfected in the case of removal or death No child under fifteen should reside in the same house on any account All movements of patients must be reported at once to the medical inspectors any dressings used for their sores should be burnt, or boiled for half an hour In short every possible precaution against infection must be rigidly enforced on the penalty of removal

to an institution in the case of any default. These measures also have great educative value in impressing on the people the dangers of the disease.

The Prohibition of Certain Occupations to Lepers.—Powers are necessary prohibiting on pain of segregation all sufferers from leprosy from following certain trades in which there is special danger of their infecting others. These include occupations concerned with the sale or preparation of foods the making of clothes and cigars, the care of children or the sick, domestic servants, hospital dressers or dispensers, midwives, wet nurses, barbers and prostitutes this important measure should be enforced in all countries where leprosy is indigenous.

* * * * *

It will be clear from the foregoing discussion and from the data in *Table I* that compulsory isolation even in its recent modified form, has only been attempted in such limited areas that it barely touches the fringe of the problem as a whole. We must therefore look for a more practicable and less costly method of separating the infective cases from the healthy if any material reduction of the leprosy incidence of the world is to be accomplished Fortunately the attractive power of the improved treatment has opened the way through the voluntary leprosy colonies next to be described Also, in contrast with compulsion from an outside source, coercion from within the community as the result of an educational campaign is often successful. This may be accomplished through the Propaganda Treatment-Survey System.

PRELIMINARY SURVEYS AND PROPAGANDA

The first essential is to know the nature and extent of the problem to be dealt with in any area or country Under the old compulsory segregation method the inevitable hiding of most of the cases made this impossible Hence its failure to reduce the incidence of leprosy in most countries.

A survey of either the whole population in small countries or of sample areas of large ones constitutes the first step, for the success of which it is necessary to obtain the confidence and co-operation of the people In India and elsewhere the best plan to allay suspicion was found to be to open special out patient dispensaries or to arrange for the treatment of leprosy patients on certain days at already existing hospitals and d[illegible]ies. The patients could then be informed that others [illegible] are likely to be sufferin[illegible] unsuspected [illegible] useholds of the

disease and permission obtained to visit their homes and examine all the inmates for any such early cases with a view to their treatment while still in the most amenable stage. As confidence is thus established examination of the whole population of villages will become practicable and the extent, type and distribution of the disease will become apparent with a great increase of the cases attending the clinics for regular treatment.

The results of surveys of nearly two and a half million people in India by Muir and his assistants has already been recorded (p. 33). The health report of 1940 for the Indian Province of Orissa states that the examination of 822 629 persons in 2271 villages led to the discovery of [illegible],699 cases of leprosy and 129 more were detected among 14,000 school children. An increase of 247 isolated infective cases brought the total up to [illegible],82 and 40 825 earlier ones were undergoing treatment as out patients at dispensaries with improvement at the end of a year in over 90 per cent of them. Yet the total anti leprosy expenditure among the population of seven million amounted to only £1544 annually against about £200 per case isolated in New South Wales, for example. In the Belgian Congo about 10 000 cases were discovered in 1939 in addition to 60 363 cases found by earlier surveys. In the Kengtung Shan State of Burma a survey during 1939–40 of about 10 000 people revealed 609 cases of leprosy, 61 per mille. For other surveys reference may be made to the Philippines (p. 31), Ceylon (p. 32) and Trinidad (p. 44).

VOLUNTARY LEPROSY AGRICULTURAL COLONIES

At an all India leprosy conference in Calcutta early in 1920 Rogers advocated the development of large agricultural colonies in the country in place of the prevalent prison-like walled Government leper asylums in the outskirts of large cities. Each should have ample land to cultivate so as to provide occupation for the active inmates to the benefit of their health, and in order to contribute materially to the upkeep of the institution. A specially trained medical officer should be placed in charge to allow the best treatment to be carried out and only infective cases admitted whose voluntary isolation for the sake of the treatment supplied would help to reduce the spread of the disease. Old uninfective burnt-out nerve cases may be accommodated as a humanitarian measure in the less well-equipped and staffed old type asylums. Some of the Mission to Lepers institutions already situated in

country areas are suited for development on these lines. Unfortunately after the lapse of over twenty years the Lady Willingdon Leprosarium in Madras and the Dichpali Leprosy Hospital are the only large new and modern institutions to be founded in India. The British Empire Leprosy Relief Association, founded in 1923 in London with an active Indian branch, has developed this policy in British African territories more particularly.

In **India** the long standing Purulia mission colony with over 700 resident cases and numerous earlier ones attending for out patient treatment, and the Lady Willingdon Government colony near Madras, are the best examples of modernized institutions. The new treatment has been so effective at Purulia that there is now a village of recovered patients who support themselves on mission land. This development solves the difficult problem due to the relatives of recovered cases being afraid to take them back and allows of their being watched for relapses and again treated if necessary somewhat on the lines of the successful tuberculous colony at Papworth near Cambridge.

The Dichpali leprosy mission hospital, founded by the Rev George and Dr Isabel Kerr in the Hyderabad Deccan is another modern development due to the success of the improved treatment in comparatively early selected cases. At first all types of cases were admitted but later they were restricted to patients likely to benefit by active treatment, no deformed arrested cases being taken in. The whole was on a voluntary basis but with many times the applicants for admission that could be provided for. Many hundred Indian doctors have been also instructed there and at the Calcutta School of Tropical Medicine in prophylaxis and treatment, so that the knowledge acquired is widely diffused. A Dichpali report recorded that about 90 per cent of the patients were being discharged symptom free, although doubtless some relapses occur. Moreover it was found that the infectivity is greatly reduced by treatment, as shown by the early disappearance of lepra bacilli from the nasal secretions.

In **Nigeria** the voluntary colony system has been extensively developed, mainly under missionary doctors with Government and philanthropic financial support, as the most effective and economical method of handling a very difficult problem. Volunteer lay workers, mostly recruited by Toc H, have done good work in leprosy colonies in Nigeria and elsewhere by relieving the medical staff of much routine and social work.

In 1928 Dr Mayer reported that 863 out patients and 2112 resident ones were being treated in these colonies and in 1936

there were 1500 at the Itu colony alone under Dr Macdonald with a total of 5022 under care in the colonies as a whole By 1942 the work had expanded so rapidly by the establishment of numerous out patient clinics around two of the main settlements that the Oji River leprosarium was caring for 1000 in-patients and over 13 000 out patients under Dr Money at a total cost of only £2,444 a year or 3s. 4d per treated case Likewise Uzuakoli cared for 15 166 leprosy cases in the central settlement and 54 outlying dispensaries Many more clinics were being demanded by the people.

Leper Villages for the Voluntary Isolation of Infective Cases.—Advantage has been taken of an old Nigerian custom of isolating advanced cases of leprosy in separate villages to which none but lepers were admitted With the cordial co-operation of the chiefs and the people 34 model villages have been constructed to isolate and treat large numbers of infective cases. How successful this has proved is shown by the fact that at a third survey of 7000 persons in one area not a single free infective case was found 40 new early cases were detected and their treatment arranged for at a clinic. By repeating such surveys those already infected before the contagious cases were isolated will gradually be found in an early stage and the great majority of them cleared up by treatment. As the people are clamouring for the extension of these successful methods of prophylaxis it is clear that we already possess the means very greatly to reduce the major and key problem of leprosy in Nigeria, and wherever such measures can be effectively carried out. The war is holding up the work, but the Government of Nigeria is already convinced of the value and practicability of prophylaxis against leprosy and with the help of the Colonial Development Fund even more rapid progress should result in the post war era.

In the **Belgian Congo** the Public Health Report for 1939 records that the native population also recognizes the value of leprosy isolation villages, and the administration is aiming at providing them for not more than 400 cases in each with land to cultivate so as to be self-supporting

Campaign in the Southern Sudan.—This crucial test on a large scale of the modern plan of isolation of the infective cases in an agricultural colony is of great importance. In the course of yearly routine examinations of the whole population of a large area of the rainy southern provinces of the Anglo-Egyptian Sudan for sleeping sickness, numerous cases of leprosy were observed. The Principal Medical Officer Dr O F H Atkey after consulting

Rogers, carried out his suggestion to examine all the people yearly and to move the infectious cases into colonies with efficient treatment. The survey carried out between 1927 and 1930 revealed no less than 6500 cases, 4800 of which were considered to be infective, and they were moved to thirty square miles of vacant land where they built their own houses and grew their own crops, which made them partially self-supporting. In 1932 Cruickshank reported that the isolated cases formed 84 per cent of the total, 5.3 per mille of the whole population, and included all the infectious ones. Fortunately they were mostly early mild cases suitable for treatment, and subsequent annual sleeping-sickness surveys revealed very few new cases except in the outskirts of the Barh-el-Ghazal province, where a deficiency of meat and milk diet favours the disease. In the Sudan report of 1934 E. D. Pridie recorded that in the course of five years 7075 cases were admitted to the leprosy colonies and no less than 3679 (52 per cent) recovered, mostly during the first two or three years from among the early cases. All but the advanced lepromatous cases benefited from the chaulmoogra treatment. The serious leprosy problem in this extensive and difficult area appears to be on the way to solution, though 295 new cases were admitted in 1937 of which 63 were of the lepromatous type. Delay is being caused by lack of adequate staff.

Organization of Leper Colonies.—Colonies with accommodation for up to 1000 or more lepers should include:

1. *A Hospital for Advanced and Ulcerated Cases* with small wards to accommodate all those having open lesions requiring frequent dressings. Patients with loss of digits and other deformities, who cannot be restored to health and activity by any treatment, should be separated from the earlier hopeful cases if it is necessary to admit them at all.

2. *A Section for the Earlier Patients* more amenable to treatment, who would thus not be repelled from seeking admission by having to mix with the deformed cases and be depressed by seeing how little could be done for such advanced patients. The male and female patients should have separate accommodation and not be allowed to mix. In the case of patients already married separate rooms or cottages in a distinct enclosure should be provided from which children should be absolutely excluded. Infective lepromatous and mixed cases should be separated from bacteriologically negative nerve ones.

3. *A Separate Home for Healthy Children of Leprosy Patients* who should be minutely inspected at least every three months for early signs of the disease. Microscopical examinations of any skin

lesions and of the nasal mucosa should be made in all suspicious cases to enable any children developing the disease to be removed from among the healthy and effectively treated at the earliest moment.

4 *Agricultural and Industrial Work* should be provided for all who are able to engage in it. The proceeds should help considerably towards the expenses of the colony but a percentage might be given to the workers to enable them to buy small luxuries, as at Culion

Staff—The organization of a leper settlement and the treatment and control of leprosy require a highly trained, whole-time personnel. This requires altruistic doctors and laymen who are willing to give years to the study of leprosy In the best organized institutions in the tropics and subtropics the subordinate staff consists largely of the more intelligent patients themselves who are trained to help in all activities—medical, educational social and industrial Recovered patients with this training are often useful in antileprosy public health and other such activities in their own or neighbouring villages (p 135)

Discharges from the Colony of the Apparently Recovered—In view of the relapses which have not infrequently occurred in patients who have left off treatment against advice as soon as their visible lesions disappeared and the recurrence and readmission of 12 per cent of apparently cured patients in Honolulu great caution is necessary in discharging any patients as recovered Repeated negative bacteriological examinations over a year after all clinical signs have vanished are advisable Discharges should, if possible, be sanctioned by a Board of at least two expert leprologists, and on condition that the patients are inspected every three months for several years by the Board

Separation of the Sexes in Leprosy Institutions.—Every one is agreed that it is most undesirable for leprosy subjects to beget children owing to the high probability of their becoming infected by their parents with consequent indefinite maintenance of the incidence of the disease The matter is not so simple in practice as in theory and the best methods of protecting children born to lepers have to be considered in relation to the special conditions in different countries and peoples.

The *Philippine Culion leper settlement* during its first decade or two provided a good illustration of the disastrous consequences of the omission of any steps to prevent the unrestricted breeding and infection of children this has since been remedied to a large extent (p 72) The much later organized island leper

settlement of Trinidad furnishes an example of providing well-separated colonies for male and female patients respectively. This may not prove feasible in some backward countries, especially in tropical Africa, where any attempt to separate the sexes is likely to prevent any material number of the infective cases entering the colonies, and wholesale hiding would defeat any efforts at compulsion.

The Sterilization of Married Leprosy Patients.—Owing to difficulties in backward tropical countries in the safe separation of infants from their leper parents early enough to prevent the possibility of their infection, the most effective method of preventing married patients begetting children is by sterilization. As this operation in the case of women involves a comparatively serious abdominal section, the much more simple severance of the vas deferens on either side of the scrotum under a local anæsthetic in males is nearly always to be preferred. This harmless procedure for preventing fertilization of the female without interfering with normal marital relations has been successfully adopted by R. M. Wilson (1935) in Korea, where he found that attempted separation of the sexes and prohibition of marriage in leper institutions led to the birth and infection of many illegitimate children. Further, patients frequently refused to stay in institutions if forbidden to marry, but left and led a married life in camps and had many children, half of whom contracted the disease from their parents and so perpetuated it. He therefore started a self-supporting section of his Korea colony by allowing patients to marry after the male partner had submitted to the minor operation of vasectomy and he allowed each couple to adopt a leper child from the colony because of their desire on religious grounds to have an heir. This common-sense plan worked well and the cost of maintenance of the married patients was one-fourth of the average. In 1936 Wilson was able to record that after three years eleven treated couples remained well and had produced no children, but among seventeen families, who had married without permission or sterilization of the men, nine children had been born, four of the mothers had relapsed under the strain of pregnancy and no orphanages would take their babies, who thus remained exposed to infection. Hayashi (1934) reported that sterilization of the husband before marriage is preferred in Japan and Peralta Ramos (1928) records the sterilization of a leprous woman after she had borne six children. This measure is not required in the case of uninfective nerve cases, and in early dermal cases the patients are likely to submit to marital separation for a time whenever there is a fair probability

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time have been adopted in various countries. In Malaya Smart (1933) reported that the children of lepers are removed from the parents within fourteen days of birth and no case of leprosy is known to have occurred among them. In the Dutch East Indies, Paneth (1930) reported that the few children born to lepers who are allowed to marry are sent to healthy relatives after being weaned. Philippine experience indicates that such late separations are far from eliminating infections, for Rodriguez (1926) recorded that at the Culion settlement the segregation of the children of patients after the age of six months does not decrease the incidence of leprosy among them or delay its appearance, so it is necessary to remove them as soon as possible after birth this has been done successfully in Hawaii and India. Nursing arrangements to allow of infants being reared when removed at birth are necessary In India Lowe records that in one leprosy institution 25 children, who had not been separated from their parents until after the age of eighteen months developed symptoms of leprosy between the ages of 3 and 10 years. In Trinidad Muir examined children in 178 schools and discovered 83 cases of leprosy in spite of many of the children having been absent. Moreover by following up the child cases to their homes many other contact cases were found these included 5 in the case of one girl and 8 of a boy A serious result of the neglect of this precaution is recorded by Lampe (1933) namely that in Surinam there were lepers born and infected in asylums who were still living in them at great total expense when over 80 years of age. See also data on p 72 and *Fig* 13

The effectiveness of very early separation of the infants born to leper parents is established by the following data. Neve concluded from his long experience in Kashmir that children of lepers at birth are free from the disease but unless separated from their parents they are almost sure to develop it within a few years. Canon Guilford, who was for many years in charge of the leper colony at Tarn Taran in the Punjab recorded that of all those born there during the last thirty years, I know of only two men who have not become confirmed lepers, and even these, when I last saw them began to show signs of the disease upon them" This was before the establishment at Tarn Taran of the home for untainted children at a later date Mr Jackson was able to report

On the other hand, *for the same period of thirty years* the children of leprous parents of the Almora asylum have been brought up in a home apart from their parents, with the result that only one of them has developed the disease. Several of these are now

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Exclusion of Lepers from all Schools or other Institutions for Children comes under the same category and should apply to school teachers as well as pupils. Where there are numerous lepers separate schools for their children may be necessary and the infectivity of leprosy and the methods of prophylaxis should be taught in schools in endemic areas (B Sommer)

The practical application of these measures may be illustrated by the following examples. In Dutch Guiana (Surinam) Lampe (1932) reported that the regular examination of all school children had proved to be the most efficient way of discovering slight and early cases of leprosy for out of 8800 children so examined 123 had been declared infected by the medical board, 44 of them being highly so. In Uganda 150 infected children were discovered and placed in a special hospital, where they are both treated and educated under a C.M.S medical officer with the result that within a short time the first batch of recoveries were discharged Cochrane and Rajagopalan (1938) examined 1671 Madras school children and found 10.8 6 per cent, to be definite or suspected cases.

Immigration and Repatriation. — Wherever prophylactic measures are being enforced to diminish and eventually stamp out leprosy it is obvious that powers should be available to prevent the introduction of further infection by leper immigrants from other countries The data regarding the spread of the disease over the globe given in an earlier section (pp. 6–9) alone suffice to prove the necessity of this measure of protection, which has been adopted by Canada the United States of America Australia and some of the West Indian Islands. It is of interest to note

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that as early as 1763–4 the importation of lepers was forbidden in Dutch Guiana (Drognant Landré)

It has been found impossible to detect and exclude all leprosy infected immigrants by the usual port inspections on account of early signs of the disease being difficult to detect without minute examinations by experts of the whole surface of the body Owing to the long incubation or latent period of the disease persons of healthy appearance on arrival may not rarely develop leprosy within a few years after gaining admission to another country than that of their birth This was the case with a number of Scandinavian immigrants to the United States, from where leprosy patients may be deported up to eight years after their arrival.

It is therefore essential to have powers to repatriate all such lepers on the first discovery of the disease, as provided for by the laws of the countries above referred to many Japanese, Chinese and Indian subjects have been so dealt with. Any persons unfortunate enough to have contracted leprosy while abroad should not be denied the right to return to their native country although they must submit to any laws which may be in force and should have the right of admission to and treatment in any available leper institution. All immigrants from leper families or districts should be registered and watched for several years (Jeanselme)

The mere fact that any country possesses powers to exclude leprosy-infected immigrants and to repatriate those developing the disease later within the incubation period should lessen the likelihood of their trying to enter such a country A rule requiring any vessel bringing a leper to take him back to his own country at the shipping company's expense has a similar salutary effect.

LEPROSY HOSPITALS AND CLINICS FOR EARLY CASES

The improved treatment of leprosy has opened up the way to reduce greatly the most frequent sources of infection, namely infective lepers in the earlier not easily recognizable but often still infective stages of the disease they are far more dangerous than the advanced maimed nerve forms, from which it is rare for lepra bacilli to escape. We have repeatedly pointed out how difficult it is to isolate early cases in the absence of any effective treatment and that by the time they reach a stage in which they are easily recognized by the general public and are consequently shunned by them or sent to leprosy institutions, they will only too often have infected other members of their families so that their

isolation then fails to prevent the continued spread of the disease. Investigations in Calcutta showed that such cases could be detected daily in the large out patient department of the Medical College Hospital which yielded valuable material for testing the new line of treatment in patients who came once or twice a week to the research laboratory for injections.

The success of the Dichpali hospital in clearing up the symptoms and infectivity of a very large proportion of the comparatively early cases alone admitted has already been described (p 126) but this plan is limited by its cost per patient.

The Dispensary Out-patient System was advocated by the authors of this work to meet the needs of the vast number of early cases of leprosy revealed in India by investigations under the *propaganda treatment survey* system, the object of which was to win the confidence and co-operation of villagers through the out patient treatment of their cases. A survey is first carried out by examining relatives and contacts of cases under treatment. The villagers are enlightened as to how leprosy has spread in their village and what steps to take to prevent further spread. This simple and inexpensive method is carried out by a well trained staff Anti-leprosy campaigns on these and similar lines have met with success in India and have been adopted in Africa and elsewhere. (*See also* Appendix IV)

In highly endemic countries it is important that all doctors should receive practical training in the diagnosis, treatment and prophylaxis of leprosy In India the British Empire Leprosy Relief Association has arranged for the special training of thousands of doctors and leprosy is in many places treated in general and special dispensaries.

Amongst other countries now advocating or using dispensary and clinic treatment may be mentioned the Philippines with their skin clinics (p 111) and Nigeria (p 126) Smaller clinics are undertaking the same work at about 100 centres in British African possessions mostly through the agency of medical missionaries with drugs supplied from London. Maxwell has repeatedly advocated dispensaries and clinics at the various mission hospitals in China as the only feasible method of attacking the immense leprosy problem in that vast country

In Japan the official policy only recognizes the value of compulsory segregation where the census figures of leprosy in 1935 were 15 193 as compared with 14,261 in 1930 (Hayashi)

The Repeated Examination of all Contacts to Ensure Early Detection and Efficient Treatment in the Amenable Stages of New Infections.—This method has long been advocated

by Rogers as the most essential of all prophylactic measures to produce a rapid reduction of the incidence of leprosy wherever it proves feasible (p 134 of the first (1925) edition of this work) It is based on (1) the proof afforded by his analysis of 700 cases in which the probable source of infection was traced that some 80 per cent of new infections are contracted through prolonged contact with an infective case while living in the same house (p 82) and (2) if the disease is discovered in its earlier stages the duration of such exposure, commonly regarded as the incubation period averages 2½ to 3½ years and in over 80 per cent of cases does not exceed 5 years (p 162)

It is therefore advised that immediately an infectious case of leprosy is discovered the patient's house should be visited by a medical practitioner and all his family and servants closely examined for early signs of the disease, and that this should be repeated at least every six months for the next five years. By this means some 80 per cent of the infections arising from the first case should be detected in time to keep most of them from becoming infectious. If this measure were then continued for another five years, few infective cases of leprosy would be left to maintain the incidence of the disease for within the total period of ten years most of the originally infective cases would either have died or have been effectively isolated even under a voluntary system, and the problem would be largely solved

That a very large proportion of the new cases could thus be detected in the amenable early stages has been demonstrated by more recent experience. Peacock (1930) found two or more early cases in three instances. Cochrane in the West Indies found one to three unsuspected infected children among the contacts of *every nodular case of leprosy* he investigated and Moiser (1937) in Southern Rhodesia recorded that the house examination of contacts was a far more successful method of detecting new early cases than was general house to-house surveys Moreover Muir (1935) has recorded an instance of fifteen family infections in the course of a number of years traced to one case found during a village survey nearly all of these might have been detected and effectively controlled The above plan has in recent years been advocated or adopted in various countries. The most noteworthy is J A. Mitchell, of South Africa—a strong advocate of compulsory isolation—who in 1926 recorded his opinion that by six monthly examinations of contacts over five or six years and removal of the infective cases from the households the spread of leprosy in the Union of South Africa would very soon be checked

and reduced this plan has since been adopted there with advantage (p 107) In China Maxwell (1928) advocated Rogers's plan as did Austin (1932) in Fiji. Rose (1932) in British Guiana paid special attention to the examination of the families of infected persons as did Carreon in 1932 in the Philippines after finding that a survey of fifteen families of leper children revealed leper parents in twelve of them Repeated examination of old contacts with known leprosy patients played an important part in the detection of 2 548 new cases during surveys in Ceylon (See p 114.)

Nauru Island Trial of the Contact Examination Prophylaxis Plan.—The history of the introduction and rapid spread of leprosy among the people of Nauru Island in Oceania has already been described (p 35) but the use of the method of repeated examination of the inhabitants to detect and treat in the earliest stages all newly arising cases remains to be dealt with. When at Rogers's suggestion the 2500 or so inhabitants who included 1000 Chinese were closely examined for any clinical signs of leprosy almost 30 per cent of the 1500 Nauru Islanders were found to be already infected 90 per cent of them being still in the early stage of the neural type and the remaining 10 per cent lepromatous including a few nodular cases. With the exception of one district nearly every family was infected, so practically every native had been in contact with a leper The infective cases were isolated on one side of the island and the uninfective ones allowed to continue their work, but the latter were provided with separate sleeping accommodation from the healthy in case any became infective Both classes were treated regularly and the healthy were examined every month to detect further infections as early as possible bacteriological examinations of new cases were made to determine if they were infective to others. Three years later in 1930 G W Bray related the story of the reduction of the isolated cases from 189 to 132 and the uninfective ones from 176 to 86 a total reduction of 40 per cent within three years. In 1934 A. M B Grant reported that by the end of 1933 a total of 193 infective cases had fallen to 66 or approximately one-third within a decade In addition 153 uninfectious cases were attending clinics as they are not discharged as apparently cured until the lapse of five years He concluded that the decrease was mainly due to the new plan adopted, which has given better results than would have resulted with compulsory segregation of every case of leprosy Both medical officers assured the writer that scarcely any of the early uninfective patients had gone on to the infective stage while under treatment.

Section IV—AETIOLOGY

CHAPTER IX

DESCRIPTION AND DISTRIBUTION OF BACILLUS

Leprosy is caused by the growth of the *Mycobacterium lepræ* or *Bacillus lepræ* (Hansen 1871–3) in the body and the reaction of the tissues to its presence

DESCRIPTION OF THE BACILLUS

The bacillus (generally referred to as the lepra bacillus) varies in appearance according to the staining method used and the phase of the disease through which the patient is passing at the time.

1 What may be considered as the normal vegetative form of the bacillus is a uniformly staining rod straight or slightly curved, from 1 to 8 μ in length. When placed alongside a tubercle bacillus under the microscope it is impossible to distinguish the one from the other with any certainty but lepra bacilli are generally found adhering closely together in large bunches, described as cigar bundles surrounded and held together by a lipoid substance called glœa by the older writers these are more or less characteristic of lepra bacilli, and help to distinguish them from tubercle bacilli.

2 In all phases of the disease but notably in acute exacerbations (lepra reaction, *see* p 187) while many of the bacilli may retain their uniform, vegetative form, a certain proportion are morphologically altered. Parts of the rods do not take on basic dyes, and various appearances are thereby produced (*a*) Diphtheroid rods with bipolar staining (*b*) Rods containing a series of dots, giving the appearance of a string of beads (*c*) Large, round, spore-like forms with an attenuated rod projecting either at one or at both poles (*d*) Spore-like forms with no rod projecting (*e*) Thin, uniformly stained rods. It is not known to what extent these forms indicate disintegration of bacilli, but they are sometimes an indication of the phase through which the lesion is passing, and of the manner in which the disease is progressing (*see Fig* 75)

Lepra bacilli are acid fast, and are not easily decolorized by either dilute mineral acids or alcohol after having been stained with basic dyes. They may be distinguished from tubercle bacilli (a) By the bunch like arrangement of the bacilli (b) By their large number (c) By their straighter or less curved appearance (d) By the sites in which they are found (e) By the fact that, when injected into guinea pigs, tubercle bacilli produce tuberculosis, but lepra bacilli fail to reproduce any disease and (f) By their staining reaction, for while lepra bacilli are more easily decolorized by dilute acids than tubercule bacilli the latter are more easily decolorized by alcohol (*see also* Villela, 1938)

Individual bacilli vary in their acid fastness. It has been suggested that there is a non acid fast form, and that the acid fast is only one stage in the development of the organism. Other workers have upheld the view that there is a filterable form Proof is wanting in support of these two hypotheses.

Lepra bacilli may be distinguished from saprophytic acid fast rods such as the smegma bacillus, by their greater power of retaining basic dyes especially when alcohol is used as the decolorizing agent

Acid fast bacilli differ from other bacteria in containing a larger proportion of ether-soluble compounds ranging from 25 to 40 per cent (R. J Anderson) There are also proteins which contain immunologically distinct antigens The fractions of lepra bacilli and their antigenic properties are referred to on page 157

PATHS OF SPREAD THROUGH THE BODY

There are three paths by which infection spreads throughout the body from the primary lesion or lesions.

1 *Through the Lymph-spaces* —Bacilli may enter the skin either by direct inoculation or as an embolus from another focus. Whether they are carried from distant parts of the body by wandering cells is not known. Passing through the walls of the capillaries they lie in the perivascular lymphatics along which they pass, or they are ingested by endothelial or macrophage cells. The bacilli, when present in large numbers in the skin may spread by direct con tinuity When in small numbers it is much more difficult to explain their method of spread The natural lymph flow may carry bacilli along in one direction but when a macule in which few or no bacilli can be found, gradually extends itself centrifugally it is more difficult to understand The question has been raised whether there is not a non-acid-fast mycelial form of *Bacillus lepræ* which has not yet been distinguished histologi cally but which is the main cause of nerve lesions and such mild

radially spreading lesions as fail to show acid fast bacilli on microscopical examination

Bacilli appear to pass by lymphatic channels from the cutis to the main nerve trunks by way of their smaller sensory branches. They are found lying singly or in groups between the nerve-fibres.

2 *By Metastatic Spread through the Blood stream.*—It is difficult to explain how bacilli enter the blood-stream. It may be by entering the capillaries of the skin direct or by passing along the lymph spaces into the lymphatic vessels and thence through the lymph nodes into the thoracic duct and the superior vena cava. We have discussed this elsewhere (p 150)

3 *By Auto-inoculation*, the patient re-infecting himself through abrasions or by scratching the nasal mucosa or skin surface.

DISTRIBUTION IN THE BODY

1 Lepra bacilli have been found in the *corium* of the skin over almost the whole body It was formerly supposed that the scalp the soles of the feet, and the palms of the hands were exempt but these parts are frequently affected, though the thickness or tension of the skin may render signs of leprosy inconspicuous.

2 The *mucous membranes* of the nose, mouth, and pharynx are affected in most advanced lepromatous cases

3 The *eye* is often affected both in its superficial and deep structures.

4 The *lungs* are seldom affected to any great extent, but in advanced lepromatous cases the bacillus may be seen in the cells in and surrounding the blood-vessels in the interstitial tissue (p 202)

5 In advanced lepromatous cases the *liver* is generally affected bacilli are found in the interlobular connective tissue and round the central veins the Kupffer cells may become swollen with bacilli, but they do not penetrate the parenchymal cells According to Hansen, the glands in the hilum of the liver are, when that organ is affected with leprosy definitely leprous, and the affection of the glands is often more evident than that of the liver itself

6 In advanced and acute cases of leprosy the *spleen* may be involved The affection has its seat in the arterial sheaths and the Malpighian bodies. Hansen has found leprous glands in the hilum of the spleen when that organ is affected

7 Mitsuda, using special stains to show up lepra cells, found leprotic tissue in the *œsophagus stomach,* and *intestine* The number of bacilli was small the lesions were along the capillaries and principally in the region of the muscularis mucosa. The

corresponding mesenteric glands were involved Absence of ulceration is a characteristic of intestinal leprosy and there seldom ever is any clinical disturbance.

8 Mitsuda states In cases of nodular leprosy the bacillus is unmistakably present in the glomerulus of the *kidney* where it causes hyaline degeneration of the glomerulus and interstitial nephritis it is probable that the bacillus lives in the endothelium of the capillary veins Disease of the kidney is in some places a common cause of death in leprosy but whether this is caused by invasion of the glomerulus or is the result of absorption from trophic ulcers and mixed infections elsewhere in the body requires further investigation

The *bladder ureter* and *prostate* though they may show a few lepra cells, are not seriously affected by the disease.

9. *Suprarenals* According to Mitsuda the suprarenals are attacked in all cases in which the liver and spleen are affected Lepra cells are found chiefly between the cortex and medulla and closely adherent to the central vein Apparently however the slight lesions that occur have, unlike those of tuberculosis, no effect on the general health of the patient.

10 According to Hansen the *testicles* are affected with leprosy in all nodular cases. The affection is both intertubular and intra tubular In a testicle only slightly affected he found bacilli every where in the endothelium of the vessels, and in several dilated vessels white blood-corpuscles filled with bacilli, and in some places also bacilli lying free between the red blood-corpuscles. Especially when the affection is more marked the bacilli penetrate into the seminal canals and lie grouped round the nuclei, and the epithelial cells are more or less filled with them. "The leprous testicle is finally completely destroyed by the scarlike contraction of the connective tissues, and one finds only here and there traces of the seminal canals around the globi which they enclose.

11 *The lymph-glands* The following valuable description is quoted from Walker's translation of Hansen and Looft's book on leprosy This leprous affection of the glands is microscopically very readily recognizable. The glands are swollen as a whole without any alteration in their form. On section one sees the ampullæ and the medullary cords of a yellow or yellowish brown colour this colour gives to the glands such a characteristic aspect that they can hardly be mistaken. The affection is best studied in the inguinal glands and the retroperitoneal ones in connexion with them. The lowest inguinal gland is always most swollen, reaching sometimes to the size of a pigeon's egg the ampullæ

and trabeculæ are coloured throughout a deep yellow but the somewhat thickened capsule and the connective tissue framework have retained their greyish semi transparent appearance, so that the structure of the gland stands out very clearly especially if the lymph-sinuses are injected with blood pigment, which is sometimes the case when there have been peripheral hæmorrhages in the nodules. As we advance upwards, the glands are gradually less swollen and the yellow colouring of the ampullæ and trabeculæ is less intense, and one can further follow in the retroperitoneal glands a gradual diminution of the affection until, above the level of the kidney or rather higher normal glands are once more met with. The glands are permeable, but penetration is evidently more difficult, for the lymph-vessels leading to them are dilated especially those of the lowest and most swollen glands. With great patience and moderate pressure one can succeed in artificially injecting the lymphatics without causing extravasation. It may even be the case that only one, or at most one or two ampullæ are affected Microscopically the ampullæ and trabeculæ are found more or less filled with brown bodies or globi. These are evidently lymph-cells which have become filled with bacilli and their degenerative products—granules. One could hardly have a better demonstration of the functions of the lymphatic glands, as filters, than in these leprous glands The circulation through them is not arrested nevertheless, the glands retain the infectious product, and if it passes one gland it is arrested and retained in the next. Sometimes the quantity of this infection is so small that one or two ampullæ are sufficient to retain the whole of it. This indicates that the circulation in the gland does not take place exclusively through the lymph-sinuses, but that the lymph reaching the gland must at once enter the ampullæ. A similar process is seen in tuberculous lymphatic glands, in which one often finds only one or two ampullæ infiltrated with tubercle.

Suppurating lymph-glands are found not infrequently in skin leprosy Whether or not such suppuration takes place apart from a mixed infection it is difficult to say The glands which are most frequently affected are those of the groin and neck. The discharge is found to contain large numbers of lepra bacilli, and it is not uncommon to find patients with large discharging sinuses in the groin, which because of the large quantity of bacilli which they discharge, may possibly be a fertile source of infection, though in the present state of our knowledge it is impossible to say how many of the bacilli are alive and how many have been destroyed in the suppurative process.

McCoy records the result of examination of 10 cases of tuberculous glands observed among 650 lepers at the Molokai settlement. The axillary glands were affected in 7 the inguinal and femoral in 3, the cervical and epitrochlear in 1 case each. "In 9 of the patients there was no evidence of tubercle in other parts of the body All were adults. Now Park and Krumwiede in their study of glandular tuberculosis found that 25 only out of a total of 119 of those attacked were sixteen years of age or over moreover in no more than 8 of the 119 were the axillary and inguinal glands infected. In the glands of 2 lepers suffering from the anæsthetic form the acid fast bacilli were few but in the other 8 in which the disease was of the nodular or mixed type, acid fast bacilli were numerous hence it is probable that the glands contained both *B lepræ* and *B tuberculosis* Cultures of the tubercle bacillus were obtained directly from the glands of two by culture on egg media and in the rest by passage through guinea pigs. The growths showed little virulence to rabbits when one twentieth of a loop of a 22-day culture was inoculated intravenously also the proliferation was rapid on glycerin egg hence the strains isolated were of the human type of *B tuberculosis*

Lowe found distinct tuberculoid changes in lymph nodes excised from 6 out of 11 cases of the neural type of leprosy with tuberculoid leprides.

Mitsuda states In cutaneous leprosy the lymph-glands are affected in various degrees. In the femoral, inguinal and portal glands especially the involvement is so marked that changes are to be seen even in cases of slight degree, and in cases in which the skin lesions have become completely absorbed The finding of the characteristic greying or yellowish (lipoid) degeneration in the glands of a case is conclusive proof that it was of the cutaneous type. While the bacilli are fresh and abundant, the lipoid substance is scarce and the lesion foci are whitish and somewhat translucent but as the bacilli undergo degeneration and the lipoid material increases they become proportionately more distinct and yellowish in colour

To what extent the *bones* contain bacilli is not fully known Of 32 cases of lepromatous leprosy Lowe and Dharmendra found bacilli by sternal puncture in 16 of 18 cases of nerve leprosy examined in this way bacilli were found in only 1 case. Bacilli are frequently found in the marrow of bones removed from lepromatous patients at operation.

While bacilli are found distributed throughout the body in all these different situations, it is in the corium of the skin and mucous

membrane that the lesions are of *special interest.* We shall th
fore consider in more detail the distribution of the bacilli first in
corium and then in the nerves.

DISTRIBUTION IN THE SKIN AND NERVES

We describe in the clinical and pathological section the vari
lesions caused by the presence of the bacilli in the corium. It
been necessary to mention in outline the distribution of bacill
explaining the relationship between their locality and the clin
appearance of various lesions. We shall now describe in m
detail the spread of the bacilli through the tissues, and the eff
which they excite locally by their presence.

When bacilli find *their way into the corium,* either directly
penetrating through some breach in the continuity of the cut
or by way of the blood stream, one of three things may occ
(1) They may be destroyed by the tissues of the body. (2) T
may lie latent *for a longer or shorter time.* (3) *They may begi*
multiply and spread. The vessels of the corium are arranged
two plexuses: the superficial or subpapillary and the deep
subcutaneous. These plexuses communicate through vessels ly
adjacent to the hair follicles and sweat organs. The subpapill
plexus supplies branches to the papillae, and the deep plexus co
municates with arterial and venous vessels lying in the subcutane
tissue. The nerve plexuses correspond to the vascular ones.

The spread of leprous infection in the corium is in the lympha
channels lining the capillaries. In some lesions the superfic
plexus and its papillary branches are involved, the deeper layers
first remaining free but becoming affected later. In others t
whole thickness of the corium is involved from the beginning
yet others the spread is primarily along the deep plexus, invasi
of the superficial layers taking place along the hair follicles: t
results in the well known pebbled appearance of some tuberculo
lesions (*see Figs.* 43, 45).

Large areas of skin may become slowly infiltrated from sing
foci, or the infections from multiple closely-sown emboli m
converge and rapidly infiltrate the whole skin. From the sk
the bacilli spread up the sensory nerve branches and may inva
the mixed nerve-trunks; or nerves may be invaded directly l
bacillary emboli from the blood-stream.

Though bacilli are carried in the blood-stream to all parts of t
body, the central nervous system is seldom if ever the site of
leprous lesion. When secondary degeneration of spinal trac
takes place this is not due to bacillary invasion of the cord, but

a sequence of extensive destruction of peripheral nerves Danielssen and Boeck thought they had found certain changes in the spinal cord Marie and Jeanselme found degenerative changes confined to the medullary fibres Looft and Lie found degenerative changes in the exogenous fibres in the posterior columns and bacilli in the nerve-cells of the grey substance and the pericellular lymph-spaces. The spinal ganglia and the Gasserian ganglion have been found to contain bacilli and degenerating fibres We have ourselves found lesions of the cord in leprosy but did not consider that the spinal lesion was connected directly with leprous invasion Possibly the reason for the exemption of the central nervous system is the absence of connective tissue as it is in the connective tissue that bacilli are generally found

Wherever the infection advances there is a greater or less local cellular reaction produced—an attempt on the part of the tissues to limit the advancing invasion In the lepromatous type this attempt at limitation meets with poor success. In the neural type it may be highly successful and infection may be confined for years to a single lesion consisting of a small tuberculoid lepride and the corresponding sensory nerve.

It is the advance and retreat in the fight between bacilli and tissues that causes the protean lesions of leprosy and determines the distribution of the bacillus throughout the body

For clinical and pathological descriptions of lesions *see* Chapter XII

THE CULTIVATION OF THE LEPRA BACILLUS*

Although nearly seventy years have elapsed since Hansen discovered the lepra bacillus in 1871 there is still doubt whether the organism has ever been cultivated. Numerous observers have claimed to have done so but they differ widely among themselves in the description of their organisms and careful observers have repeatedly failed to confirm their findings The principal fallacy has been the growth in their culture tubes of one of the numerous saprophytic acid fast non pathogenic bacilli that occur on the healthy skin and mucous membranes, and even within the tissues and which are difficult to exclude without the most rigid precautions and not even always with their aid. Another source of difficulty is the enormous number of lepra bacilli, together with tissue cells, contained in the minced up nodules commonly used

* For further details see review by E. B. McKinley *Internat. Jour Leprosy* 1939, 7 Nos. 1 2

for inoculating culture media. The latter tend to autolyze, and a concentration of the bacilli thus resulting has sometimes been mistaken for their multiplication, but subcultures fail. The organisms that have most frequently been mistaken for the *Mycobacterium lepræ* are the following (1) Diphtheroids (2) Chromogenic acid fast cultures (3) Non pigmented acid fast cultures (4) Anaerobic bacilli. As the earlier work on these lines has been discredited a brief summary will suffice.

1 **Diphtheroids.**—These were first isolated in 1889 by Bordini Uffreiuzzi at a post mortem on a leper and grew readily on ordinary media in the same year Babes obtained on placenta-extract agar organisms like these from twelve cases. In 1901 Kedrowski grew similar organisms from excised leprous tissues, which have been the subject of much study they were recovered from rabbits eight months after inoculation. In 1911 Bayon cultivated a similar acid fast bacillus to that of Kedrowsky and after injecting it into the peritoneal cavity of mice recovered it from their lymphatic glands Acid fast bacilli, however are known to survive for long after inoculation in animal tissues, and unless they are pathogenic to some animal we have no means of ascertaining if they retain their vitality or not. Williams in India, Duval, and Walker have repeatedly isolated the same class of diphtheroids from leprosy patients, but no reliable proof of their pathogenicity to animals has been forthcoming Walker described four types of diphtheroids he cultivated from the nose and open skin lesions of sixteen leprosy cases Some of them were extremely pleomorphic, showing coccoid, long and occasionally even streptothricoid forms He did not obtain them from nerve cases or from those whose acid fast bacilli had disappeared under treatment. He considered that diphtheroids obtained from leprous lesions by various workers are identical with those cultivable from smegma preputii.

2. **Acid-fast Chromogenic Cultures.**—Among those who have cultivated this class of bacillus from leprosy cases may be mentioned Rost in India in 1905 Clegg in the Philippines, Duval, and Walker in California. Clegg grew his organism in symbiosis with cholera vibrios and amœbæ in a medium containing only traces of nutrient substances. Duval reported obtaining with Clegg's bacillus, on inoculation into Japanese waltzing mice and into two *Macacus rhesus* monkeys, lesions like those of human leprosy An organism which is similar to Clegg's bacillus has been cultivated in the same medium from smegma preputii, so that it is also probably a contamination

3. Acid-fast Non-pigmented Bacilli.—This class of organism was cultivated by Weil in 1905, Marchoux in 1911 Duval and Weldmann in 1912 but there is no evidence that it is the cause of leprosy

4. Anaerobic Bacilli.—In 1892 Ducrey obtained anaerobic bacilli from excised leprous nodules and Serra also in 1910 but animal inoculations were negative.

Fraser and Fletcher sum up their thorough investigation, in which they used the methods of Clegg Rost, Williams, Duval, and Bayon without positive results Material for purposes of cultivation on various media has now been obtained from 32 non-ulcerating nodular cases of leprosy and 373 inoculations made on the various culture media. It is curious, in view of the findings of other investigators, that we have consistently failed to obtain a culture of the *Bacillus lepræ* There can be no doubt but that material swarming with bacilli has been employed on each occasion This was clearly demonstrated by the microscopical examinations which were made in every case. From the examinations made of nodules which have been incubated on culture media for periods ranging from a few days to nine months no evidence has been obtained that the bacilli had increased or lessened in number Those investigators who have recorded an increase in the number of organisms as a result of microscopical examination must surely have failed to observe the bacterial richness of the material employed for inoculation. Anyone who has examined smears prepared from freshly excised leper tissues must be struck with the enormous masses of acid fast bacilli present, and we are unable to comprehend how it is possible to state, in a case where no microscopic growth is apparent, that an increase, recognizable only by the microscope, has occurred.

More promising results have been obtained by cultivation under various tensions of CO_2 and O_2, and the use of extracts of embryonic cells and tissue cultures In 1930 Wherry claimed to have cultivated the leprosy bacillus on a glycerin egg medium in the presence of carbon dioxide and but little oxygen gas Duval and Holt failed to confirm this observation, but in 1932 Soule and McKinley with hormone glycerol agar and a gaseous environment of 40 per cent O_2 and 20 per cent CO_2, obtained subcultures, but they were not pathogenic to animals. In 1933 McKinley and Verder reported the advantageous use of chick embryo and embryonic liver and spleen tissue in their culture media. Salle and Moser in 1937 used minced embryo media for the cultivation of both human and rat leprosy bacilli, but also claimed success with minced organs of

adult rabbits, etc. in Tyrode's solution. Both acid-fast and non acid fast rods were obtained and in subcultures the former were numerous at first but became progressively fewer These appear to be the most promising results yet reported, but until rats have been infected with subcultures of Stefansky's bacillus the many fallacies that have for so long hampered these investigations cannot be excluded. Lowe has failed to confirm the recent claims of successful cultures in gaseous media and on minced embryo or tissue cultures In the opinion of the International Congress of Leprosy held in Cairo in 1938 *the fact that results reported by* various individuals or groups of workers have not, in the majority of instances, been duplicated by others although many attempts have been made with this end in view leads to the opinion that the problems of the *in vitro* growth of the causative agent of leprosy have not yet been solved satisfactorily

Recent work on the chemistry and antigenic reactions of fractions of acid fast bacilli including *B lepræ* shows definite distinctions between the latter and other acid fast bacilli. This is likely in future to prove a useful means of confirming or disproving supposed cultures of *B lepræ*

ANIMAL INOCULATION

Numerous attempts to produce active and progressive lesions in animals inoculated with human leprous material containing innumerable bacilli have met with little success The acid fast bacilli may indeed be found months afterwards and sometimes produce local reactions of a temporary nature, which tend to resolve It is not, however possible to decide if they retain their vitality The most promising results have been obtained in the case of rats, monkeys, and recently hamsters but many of the claims have not been substantiated by other observers.

Lesions in dancing mice were first reported by Sugai and Duval Several workers, such as Ota and Sata and Catacuzene and Longhin, have reported lesions in rats, but de Souza Araujo failed to obtain evidence of anything but the mechanical transference of numerous acid fast bacilli and no multiplication in the animal tissues. In Japan, Nakamaur and others reported obtaining lesions, not in white rats, but in young house rats after removing their thyroids and parathyroids Watanabe found that repeated inoculation of rats and monkeys with human leprous material produced increased tissue reactions of an allergic nature. Progressive and transferable disease does not, however appear to have been obtained in this class of animal

In monkeys local skin lesions of a transient nature have been produced by several observers, such as Nicholle and Blaizot, Marchoux and Bourret, and Reenstierna confirmed later by McKinley and Soule in 1932 The last named obtained nodular lesions at the sites of injection after eighteen to twenty days with the formation of granulation tissue containing acid fast bacilli After progressing for a week or two the lesions gradually retrogressed and disappeared in three or four weeks, the animals showing great resisting powers against the infection. Sellards and Pinkerton also failed to obtain extensive lesions in monkeys with human leprous material but appear to have been more successful with rat leprosy inoculations in *Macacus rhesus* monkeys and also in rabbits and white mice.

Of greater importance is the infection of the golden or Syrian hamster with both rat and human leprosy In 1936 and 1937 Balfour Jones reported the successful infection of these animals by subcutaneous and intraperitoneal injections of rat leprosy material, and in the latter year Adler at the suggestion of Sir Patrick Laidlaw inoculated a series of these animals and succeeded in infecting three out of four by removing the spleen and inserting lepromatous material in the wound In the following year Burnet infected a non-splenectomized hamster by inserting a piece of human leprosy nodule under its skin with the development of a cellular lesion containing numerous acid fast bacilli. Other experiments were negative. If such infection can commonly be produced the way will be opened for chemotherapeutic tests with a view to finding more effective methods of treatment of leprosy in mankind.

RAT LEPROSY

In 1903 Stefansky in Odessa and Dean in England independently found a disease in rats, especially *Rattus norvegicus* characterized by the presence of very numerous acid fast bacilli closely resembling those of human leprosy in lesions of the skin glands and internal organs. This disease has since been found in many parts of the world, including a number of European countries with little or no indigenous human leprosy The incidence in rats varies in different places from under 1 per cent in some to 45 per cent in Odessa and is more frequent in adult animals

In the typical disease the skin shows white nodules up to the size of a pea, which may ulcerate at points liable to trauma. Lesions are common at the root of the tail. The glands are also involved especially the inguinal axillary and cervical groups, and they may soften. Visceral lesions may also occur in the liver and spleen.

At post mortem rats may show glandular affection in the absence of skin lesions In severe cases the superficial muscles are in volved The sexual organs may become infected in the last stages of the disease.

The bacilli are acid fast and are mainly intracellular but may be found in vacuolated cells They closely resemble those of Hansen, but do not form globi or bundles of organisms. Lowe found them to be able to survive for several weeks at a temperature a little above freezing if kept in a moist condition, but they are killed by a temperature of 60 C. for fifteen minutes.

The disease is readily inoculable from diseased to healthy animals and may be transmitted through the slightest abrasion but not through the intact skin Subcutaneous, intradermal intravenous, and intraperitoneal injections are all effective. Marchoux and Sorell have also produced infection through the nasal and genital mucous membranes. Transmission by feeding has only occasionally been successful, and insect and congenital infections are of doubtful origin The usual method of infection though the skin is in accordance with our present knowledge of human leprosy

The results of attempts to cultivate Stefansky's bacillus of rat leprosy is also closely similar to those with the human leprosy bacillus. Dean in 1905 Hollmann in 1912 Bayon in 1913 and others cultivated acid fast bacilli of different types, but these are now regarded by most authorities to have been non-pathogenic saprophytic bacilli, as many other careful workers have obtained only negative results. Salle in 1934 described multiplication of the bacilli in chick embryo extract media in the form of a pleomorphic organism, but he does not appear to have reproduced the disease in rats with his cultures. Lowe tested both the older methods and tissue culture ones with negative results, and considers that Salle's apparent success was in reality only mechanical transference of the very numerous bacilli in the rat leprosy tissues he used, and he thinks it extremely doubtful if Stefansky's bacillus has ever been successfully cultivated. Marchoux found rat leprosy in a human subject, the only reported case. (*See* Lowe, 1937)

BACILLÆMIA

Bacilli are undoubtedly carried in the blood-stream from one part of the body to another It must therefore be possible to find bacilli in the blood at certain times. It is chiefly reactions that bacillæmia is found, as at that tissue is broken down and bacilli T

ways in which bacilli may enter the blood stream (1) Through the lymph vessels and the left innominate vein (2) From leproma by erosion of a vessel (3) Carried by infected histiocyte (monocyte) cells into the blood-stream Erosion of vessels is not known to be a common occurrence in leprosy multiple lesions starting from foci apparently of a metastatic nature occur in the neural type of leprosy when leproma is not likely to be present It is therefore probable that wandering cells have some part in the dissemination of bacilli The bacilli in the blood are found to be either free in the serum or contained in leucocytes chiefly in mononuclears

The importance of bacillæmia is connected with such questions as the transmission of leprosy by sucking insects and child infection *in utero*

Some workers have suggested that examination of the blood in thick films taken from the skin is a useful method of diagnosis of leprosy They have claimed to find bacilli even in neural cases These claims have not been substantiated by more careful observers. If blood for making a thick film is squeezed from the skin, bacilli are likely to be extruded from the tissues along with the blood even apparently healthy skin will often harbour large numbers of bacilli.

A better method of taking blood is by vein-puncture, a larger quantity being drawn and examined after clearing and concentrating But even here the needle may be contaminated by passing through lepromatous skin unless careful examination of smears from the skin round the point of puncture has shown it to be negative.

Lowe's modification of Crow's technique (1933) is perhaps the most thorough that has been devised. With a sterile syringe and needle the antecubital vein is punctured in an area of apparently healthy skin and 4·8 c.c. of blood is drawn off and evacuated at once into a sterile centrifuge tube containing 1·2 c.c. of 5 per cent sodium citrate. The supernatant fluid is then removed with a sterile capillary pipette, and the blood-cells are left. To this residue about 7 c.c of 25 per cent alcohol is added and the tube shaken. This dehæmoglobinizes the red cells The tube is then centrifuged for 10 minutes and the fluid again pipetted off Only the white cells are now left. To this residue add 1 c.c. of 10 per cent antiformin, and shake thoroughly This dissolves the white cells, and at the same time precipitates some albumin. Leave the tube standing for 5 to 10 minutes until the cells are completely disintegrated Then add about 6 c.c. of 30 per cent alcohol mix thoroughly and centrifuge again Pipette off the fluid. A

small amount of white residue is left at the bottom of the tube. This consists of cellular debris and bacilli if present. Smears of this residue are made with a platinum loop on an albuminized slide, fixed by heat, and examined. Two hundred fields should be carefully examined.

Lowe, using this method, examined 23 cases of the neural type and found 2 positive (2 bacilli in one and 3 in the other) Examining 51 of the lepromatous type, chiefly advanced cases he found bacilli in 28 and generally very few One hundred neural cases examined by the thick-smear method had all been negative so that the more elaborate technique gave, as would be expected, more accurate results In 21 of the lepromatous cases showing bacilli in the blood from the vein, bacilli were demonstrated in smears taken from the skin at the site of puncture although no apparent lesion was present. It is therefore possible that some of the apparent blood positives were false.

WAYS OF ESCAPE OF BACILLI FROM LEPERS

Bacilli may excape through any *breach of the cuticle* of lepromatous skin, caused either by mechanical injury or by reactionary changes. Ulcerating nodules or other thick lepromatous lesions may continue to discharge bacilli and not heal up until much of the lepromatous tissue has been shed Such ulcers must be carefully distinguished from trophic ulcers which do not, as a rule, contain lepra bacilli. When trophic ulcers do contain lepra bacilli, it is generally the result of a former lepromatous lesion which has subsided but has left a few lepra bacilli in the area.

In cases with widespread lepromatous lesions clumps of bacilli are not infrequently found on epithelial scales scraped from the skin surface, these bacilli having apparently been extruded through the cuticle without abrasion of the surface. During lepra reaction bacilli may be shed in large numbers from the skin surface, not only where there is actual ulceration, but also where there is epithelial exfoliation (p 187)

The *nasal secretion* in lepromatous leprosy especially in cases with marked lesions of the face, may contain large numbers of bacilli This tends to be increased during lepra reaction In some cases where there are no external signs of the disease visible, bacilli may be found in the nasal discharge. Such patients are a special danger to the community as they may spread the disease without knowing that they are suffering from it.

Jeanselme in 1897 first found lepra bacilli in the nasal mucus of 61 5 per cent of 26 lepers Stricker found bacilli in 128 of 153

lepers or 83·66 per cent. Auche in New Caledonia found 48 in 64 cases or 75 per cent Kalls in South Africa found bacilli in 100 per cent of 45 tubercular cases in 22 of 30 mixed or 73 33 per cent and in 21 of 60 anæsthetic cases, or 35 per cent Thiroux examined 200 cases and found bacilli in 90·32 per cent of tubercular and in 15·94 per cent of nerve cases Lebœuf obtained positive results in 84 per cent of 25 nodular 92 per cent of 105 mixed and 47 per cent of 74 nerve cases. Lie in Norway obtained positive results in 92 per cent of 50 nodular and 4 per cent of 92 nerve cases Hollmann in Hawaii found positive results in 89 6 per cent of 58 nodular 66·6 per cent of 6 mixed and 45 9 per cent of 11 nerve cases Kitasato in Japan examined the nasal mucus of 68 healthy persons, the issue of lepers or living with them and in 8 found very numerous bacilli in the epithelial cells He thinks this the initial stage of leprosy

Our experience in Calcutta with dispensary patients is in marked contrast to some of the above figures Out of 206 lepromatous and mixed cases examined 37 per cent gave positive nasal smears while out of 103 neural cases, in which acid fast bacilli could not be found in the skin, only 3 8 per cent gave positive nasal smears This difference is probably due to two causes (1) The dispensary from which these cases were gathered attracts comparatively early cases we have found in more advanced cases such as those who are segregated in leper asylums a much larger percentage of positive nasal smears. (2) The absence of uniformity in standards of classification in old records makes comparison inaccurate. The Cairo Congress classification (p 173) would exclude from the neural type the majority of the cases above regarded as nerve cases

Several observers have found that the administration of potassium iodide facilitates the finding of lepra bacilli in the nasal mucosa when given an hour before the examination is made. But this is hardly the case if the method of taking material advised on p 219 is used.

Ulcerated tubercles in the *throat* are also a source of infection, and in coughing sneezing and even speaking the bacilli are projected over a metre and Auche found bacilli in the throat of 7 out of 27 examinations made, and in 5 out of 24 samples of sputum including mucus coughed up Morax, in 6 lepers with ocular lesions found a very few bacilli in the conjunctival secretions of one only and Auche found them twice in 25 examinations both cases having ulcerated lesions

Swallowed lepra bacilli may be passed in the *stools* and be a

possible source of infection. The *milk* of female lepers may contain the bacilli. The *semen* may sometimes contain bacilli, as they occur in masses in the testicles and even in the vesiculae seminales (p 141) Babes says the *ovaries* may be affected, but it is doubtful if these are invaded The *vaginal mucus* may show acid fast bacilli (p 81) but it must be remembered that other acid-fast bacilli may occur here (Thiroux)

Hollmann 1915 gives the following figures The saliva of 53 lepers was examined 317 times acid fast bacilli were demonstrated in 13 of the specimens which were obtained from 10 nodular cases with lesions in the mouth, that is in 21 7 per cent. Acid fast rods were detected 7 times in the sputum of 4 of 31 lepers suffering from cough, but in 3 of the cases the sputum inoculated into guinea pigs set up tuberculosis The urine of 48 lepers was examined 377 times acid fast bacilli were found on 15 occasions in the urine of 8 nodular cases, or in 7 1 per cent of nodular lepers. The faeces of 4 nodular cases were examined 671 times with negative results. Two hundred and fourteen samples of sweat were obtained from 48 lepers acid fast rods were demonstrated 8 times from 6 nodular cases, or in 14 2 per cent of patients suffering from this type of leprosy Acid fast bacilli were found in the tears of two lepers with lesions of the sclerotic, or in 14 2 per cent of nodular cases. Altogether 205 specimens of the lachrymal secretion of 41 lepers were stained.

IMMUNITY

There seems to be little doubt that there is natural resistance to leprosy which varies in degree in different individuals. Thus, of those exposed to infection, some acquire the disease, while others who have been exposed to an even more intense or more prolonged infection escape. This may be partly dependent on the general health of the person infected, as debility whatever the cause, lowers the resistance to leprosy But debility alone does not give a complete answer for those in excellent health may succumb to infection while debilitated patients escape Varying individual resistance to leprosy is also shown by the type of disease. The neural type with tuberculoid lesions and few bacilli indicates comparatively high, and the multibacillary lepromatous form comparatively low resistance. In the former the *lepromin test* (*see* p 156 and *Fig* 48) is as a rule strongly positive, but in the latter negative and it has accordingly been suggested that this test may be used even in non-leprous subjects to ascertain their degree of resistance to the disease. Rotberg, applying it in non leprous

children of lepers, found that positives increased with increasing age, reading about 50 per cent round about the age of ten. This phenomenon has generally been taken to indicate that resistance is low in young children but gradually rises as they grow older but Rotberg advances another theory According to him children are born either with or without the N factor and only those with this factor develop immunity on contact with leprosy those without it remaining comparatively susceptible the positive lepromin test is a sign of immunity (*see* Chapters VI XIV XVI)

There is evidence, however that as in tuberculosis resistance may be broken down by massive or repeated infection while slight infections may tend to raise the resistance.

Marchoux and Chorine have suggested that the comparative susceptibility of children to leprosy is the result not of physiological factors but of the thinness of the skin and the greater opportunities for superinfection

Another indication of the resistance of the human body to Hansen s bacillus is the frequency of abortive cases slight though definite lesions appearing and clearing up again either without apparent cause or following on improvement of the patient s health

It is well known that in advanced lepromatous cases the infection occasionally dies out spontaneously leaving the patient badly crippled but free from all active disease It is difficult to account for this phenomenon apart from a certain degree of acquired immunity

The inheritance of acquired immunity is a matter about which we have still very little clear knowledge In the Pretoria Leprosarium in South Africa nearly 100 per cent of the European patients admitted are of the lepromatous type, while only 25 per cent of the native Africans admitted to this and the other leprosaria in South Africa are of this type Lowe found in Burma that leprosy was of a much more severe type in Burmans than in Indians living in that country Some writers have upheld the hypothesis of racial immunity as the result of prolonged and severe contact with leprosy at some previous period in the history of the race. The disappearance of leprosy as an endemic disease has been explained on this basis. There is, however little direct evidence to support this hypothesis. It is easier to explain the persistence of endemic leprosy in certain European countries and its disappearance from others on the basis of sanitation and standard of living than on that of racial immunity The application of the *lepromin test* by Oldberg in South America in children of

foreigners and natives did not show racial differences but interesting results might be obtained by further extensive use of this test if it is accepted as a criterion of individual immunity to leprosy (*see Lepromin Test* below)

Dharmendra and Lowe state that a study has not yet been made of the possibility of turning a lepromin-negative healthy person into a lepromin positive, by means of injections of lepromin. If this were possible, the question whether such a change was followed by increased immunity could then be investigated.

Statistical inquiry in America into the prevalence of the infection of the sib when one of a pair of twins, and especially of identical twins has tuberculosis, gives concrete evidence of inherited susceptibility in that disease. A corresponding inquiry in leprosy would be much more difficult because of the undeveloped nature of the countries in which leprosy is most common but the resemblance of the two diseases points to the possibility of similar susceptibility in leprosy (*See* p 59)

Cochrane, after a five years study of 245 cases of leprosy and analysis of their intrafamilial open contacts, concluded that while it cannot be categorically stated that family susceptibility has no influence in the more serious lesions of leprosy the evidence so far available indicates that this is not a major factor in the epidemiology of the disease (Cochrane and Rajagopalan)

Acquired resistance to leprosy is shown by the tendency in lepromatous cases to spontaneous elimination of infection (p 204) Local tissue resistance is observable in active lesions, especially those of the tuberculoid type. In lesions of the ring type, as the active inflammation spreads at the margin the disease dies out at the centre, leaving only slight discoloration and perhaps a mild degree of permanent sensory change or the major tuberculoid may flare up and die down leaving only a slight scar (*see Figs* 52 53 55 56)

Much investigation is still required but from the above observations it appears that there are three distinct forms of resistance in leprosy —

Natural —Present actually or potentially in the great majority at birth.

General —Variable and dependent on general health. Impaired by complicating diseases, malnutrition, climate, and other factors.

Acquired.—Systemic, shown in healing of the lepromatous type. Local, shown by healing in the centre of leprides.

The **Lepromin Test** was originated by Mitsuda. It is performed by injecting intradermally a sterilized suspension in saline of

ground up leproma The suspension contains large numbers of lepra bacilli as well as the other elements of leproma If the reaction is positive a nodule appears at the site of injection after a period of seven days and gradually increases up to about the twenty-first day when the degree of positivity is estimated in millimetres by measuring the base of the nodule (*Fig* 48) There is also a slight immediate reaction within 24 or 48 hours. Lowe and Dharmendra in a series of articles have studied the nature of the lepromin test. By isolating bacilli from the other elements of leproma and grinding up the bacilli they obtained a stronger and accelerated immediate local reaction usually in 24 hours and practically no late reaction There was also a focal reaction in distant existing lesions. They explain the delayed reaction and nodule formation in the original Mitsuda test by the slow breaking down of bacilli and consequent slow liberation of antigen and the slight immediate reaction in that test by the small amount of already broken down elements injected along with the whole bacilli. When, therefore, bacilli are ground up before injection the antigenic elements are able to cause immediate local reaction and part of these elements carried to other parts of the body can cause focal reaction A previously held theory that the immediate and delayed reactions are due to different antigens is thus disproved. The fact that injection of suspension of powdered bacilli causes immediate reaction in many of those who have had no possible contact with leprosy proves that the test is of a different nature from the tuberculin test, which is positive only in those who have had a previous contact with tuberculosis.

Further experiments of Lowe and Dharmendra show that the antigenic power of lepra bacilli lies in their protein fractions alone, neither the other fractions nor the other contents of leproma causing reaction They consider however that because of the difficulty in extracting these proteins it is better to use a saline suspension of the separated and partly defatted bacilli as the antigen in doing the test

The lepromin test is of no value in the diagnosis of leprosy Its value lies in the help it gives in distinguishing lepromatous from neural cases, the former giving negative and the latter positive results. The negative results in lepromatous cases have perhaps an analogy in the negative tuberculin test in advanced cases of tuberculosis. The technique used by Lowe and Dharmendra for preparing the partially defatted antigen and performing the test is given in Appendix II (*See* Dharmendra and Lowe 1943)

Section V—CLINICAL

CHAPTER X

THE PRIMARY INFECTION—INCUBATION—MODE OF ONSET

The lesions of leprosy are caused by the presence of *Bacillus lepræ* growing in the tissues of the body and the local reaction of the tissues to the bacilli. It is a long protracted disease and may end fatally but it has a tendency towards self healing, frequently associated with deformities

While other parts are affected, characteristic lesions are chiefly those of (1) the skin and subcutaneous tissue, (2) the mucous membranes of the nose, mouth, and pharynx, and upper respiratory passages, and (3) the peripheral nerves

THE PRIMARY INFECTION

This has not yet been fully traced, but the probability is that the bacillus reaches the corium of the skin or mucosa of the nose, mouth, or pharynx through some breach of continuity of the epithelium (pp 85–94)

The analogy of tuberculosis would lead us to suspect that leprosy might be transmitted by means of the food. Jonathan Hutchinson maintained that the bacillus found its way into the body through this channel in the medium of badly cured fish (p 61) The facts that leprosy of the stomach and bowel is practically unknown even in the advanced stages of the disease, and that in early cases leprosy of the mouth and pharynx is uncommon, may be regarded as evidence against this being the commonest route of infection it is possible, however that an organism of such low toxicity may enter through mucous membranes without leaving clinical or even histological evidence of its entry The evidence given on pp 88–91 is very strongly in favour of direct inoculation through the epithelium of the skin and nasal mucosa and, perhaps occasionally the buccal and pharyngeal mucosa.

It is very difficult to be sure whether the lesion which first makes itself evident is the initial one or a metastatic infection

from some other lesion elsewhere which was not noticed by the patient, or if noticed was ignored and forgotten When several lesions appear on different parts of the body at one time they are necessarily daughter lesions from some other primary focus but when only one lesion appears and persists for a long time, without any evidence of involvement of any other part of the body the question is a more doubtful one

When there is a history of some abrasion or other injury this may either have supplied a path of entrance to the infection or bacilli already circulating in the body may have found a nidus in the injured tissues

The question of the possible connexion of insects with primary infection is discussed on pp 16 and 91

PRIMARY LESIONS IN INDIAN LEPER INSTITUTIONS

The first noticed lesions of 1056 leprous patients in leper institutions in different parts of India are plotted in *Fig* 7

The following points are worthy of notice —

1 The lesions of the patients in hilly and stony districts were most common on the feet but, where the patients wore shoes or lived in a district where the soil was alluvial and there was therefore an absence of stones which might injure the feet, lesions of the feet were less common. While we cannot be sure how many of the first lesions noticed were actual primary lesions we think that this is evidence that injury to the feet by sharp stones tends to locate early lesions in the feet.

2 It is remarkable that there were no lesions of the scalp recorded considering the frequency with which the scalp is scratched. Such lesions are however liable to be overlooked owing to their being covered with hair and the dense and tightly drawn nature of the tissue.

3 It will be noticed that these first noticed lesions are scattered most densely *on the extensor surfaces of the* body and *especially* on the parts of the body which are most lain upon at night such as the cheeks, outer surfaces of the shoulders and arms, buttocks, and outer surfaces of the thighs. The flexor surfaces are remarkably exempt, and especially the neck, as are also the middle line of the body both front and back, and the soft parts of the abdomen not supported by bone. The region of the body where the cloth is tied round the waist is especially free. These data may suggest contact infection such as would be caused by wearing the clothes or lying on the bed of an infectious leper The affected parts are also those most exposed in lightly clad people, to the bites of insects

and consequent excoriation by the nails in an attempt to allay the irritation caused and such slight injuries to the skin may have located existing infection or helped the entrance of bacilli from outside. Lesions on the cheeks and auricles may be explained in these ways to a certain extent, though many of the face infections may be caused by the disease spreading through the lymphatics from the nasal mucosa

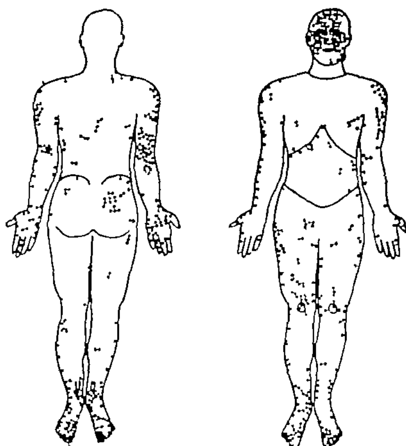


Fig 7 —The positions of the first lesions in 056 patients in leper institutions in India.

INFLUENCE OF CLIMATE

The apparent fact that leprosy is more prevalent in hot moist climates, referred to on p 11 may be partly explained by the greater softness and moisture of the skin in such climates, and the frequency of prickly heat. It may also be explained by the greater prevalence of insects with their irritating bites, and the consequent excoriation of the skin and inoculation of bacilli

Mills has attempted to explain the distribution of leprosy in relation to the effects of climate on bodily vigour since cool

changeable weather leads to high energy levels and active life whereas prolonged moist heat has the opposite effect. The latter has a stimulation index of below 3·0 on his scale and its inhabitants are cursed with leprosy but in the healthier areas with a stimulation index of over 6·0 the disease becomes mild and less prevalent and with a stimulation index above 12·0 the disease is kept up only by imported cases.

It must, however be remembered that hot moist climates are commonly inhabited by people in a low stage of civilization living in overcrowded houses conditions predisposing to infection. In the Belgian Congo and other parts of Central Africa, where the climate is hot and moist the incidence of leprosy rises to as much as 4 per cent. The people appear to be well nourished but they are insanitary in their habits. They wear unwashable kilts of bark cloth which harbour scabies and other skin infections and are interchanged indiscriminately among members of the family. The preponderance of early leprous lesions among these people was located in the parts covered by the kilt and had arisen round the scars of former scabies and septic infections.

In colder climates, where more clothes are worn the probability is that a much larger proportion of patients are inoculated through the mucous membrane of the nose. The numbers given by some observers in cold climates as to the contacts with lepers who show acid fast bacilli in the nasal secretion, far exceed the numbers we have found in India (p. 152).

Yet the fact that lepra bacilli are not found on nasal examination is no proof that the nose is not the primary site of infection. The face round the nose is a frequent site of leprides (*see Figs* 40 41 52 53, 57 65) which, except in activated major tuberculoids are negative for bacilli. The nasal mucosa is frequently involved in these leprides, and may be the immediate site of the foci from which they spring the bacteriological findings in the mucosa would therefore depend on the type and condition of the lepride.

CONCLUSIONS

While we cannot yet make dogmatic statements as to the sites of primary infection in leprosy there appears to be preponderating evidence that infection takes place in the majority of cases by direct inoculation through the skin or nasal mucous membrane.

In hot climates, where few clothes are worn more infections appear to be through the skin, and a smaller proportion through the nasal mucosa than in colder climates where more clothes are worn.

The more exposed extensor surfaces on which the patient lies at night are more frequent sites than the less exposed flexor surfaces

Where the patients wear no shoes and live in a stony country a very large number of the first lesions noticed are on the feet.

While the exciting cause in inoculation may be the bites of insects, there does not appear to be any substantial evidence that insects are, to any great extent, transmitters of infection (see p 91)

In many cases the irritation in the nose which may lead to inoculation on its mucosa by scratching with the nails is caused by intestinal parasites

INCUBATION PERIOD

REPORTS OF VARIOUS OBSERVERS

Very variable incubation periods have been given by different observers, making it most difficult to give any definite authoritative statement on the subject. Thus, Ralp Hopkins, of Louisiana, places it at 6 to 8 years Besnier says it is usually 4 years Keravel in the Caucasus found it to be 3 to 4 years in a few cases where it could be definitely fixed while Munch, of South Russia, says the disease may appear in the healthy 2 or 3 years after the death of a leper member of a family from whom the disease was apparently contracted and Impey in South Africa found the period in nodular cases to be about 2 years

Still longer periods have often been recorded Radcliffe-Crocker having reported the case of a girl developing leprosy 7 years after her return to England from Ceylon. Hansen records cases of 6 and 10 years H. M. Bracken gives the dates of the appearance of leprosy in Norwegian immigrants to the Minnesota State of North America as 1 year in 1 case, 3 to 5 years in 7 cases, 6 to 10 years in 13 cases, and 10 to 20 years in 7 cases, counting from the time of their arrival in America. The fact that infection of a certain proportion from leper relatives after their arrival in the United States was not excluded lessens the value of these figures. On the other hand Arning records that a lady from the United States, three months after coming to Hawaii, developed a red spot which became anæsthetic a year later while in two years nodules containing lepra bacilli were present and there are many cases on record of symptoms appearing within a year of a healthy person s living in close contact with a leper so that the incubation period may not rarely be shorter than the periods above mentioned.

Ehlers has pointed out that recorded very long incubation periods may rather be long latent periods after infection before

anaesthetic patches may be overlooked for years, and later exacerba-
tions of the disease mistaken for its first appearance

Important data have also been furnished from certain leper settlements. Thus G W McCoy and W T Goodhue at Molokai found four healthy attendants infected after 1 3 5 7 years respec tively and two after 12 years, the average period being 6·7 years Hollmann found the average incubation period in four accurately observed cases to be 5½ years while the average time of exposure to infection in cases developing after cessation of exposure was also 5 years, the danger increasing in direct ratio to the length of exposure.

L. Gomez, J A. Basa and C. Nicholas have studied the appear ance of leprosy among the children of lepers living with their parents in the Culion settlement of the Philippines, with the following instructive results. The disease developed in 22 child ren, who had been isolated from their infected parents at ages ranging from 11 months to 4 years, within periods varying from 4 months to 4 years after their removal from infection (*Table XIV*)

Table XIV —Leprosy in Children of Infected Parents at Culion

Periods in Years		-2	2-3	3-4	4-5	5-6	6-8	10	Totals
Number isolated from parents at diff r nt g periods	1	7	5	2	4	1		—	22
Number of cases showing period f incub tion after isolation	4	6	9		1	—	—	—	22
Number of cases showing ages t which symptoms appeared	—	—	3	6	2	5	5	1	22

The contact period averages out at 3 years Infection must have taken place some time during the contact period before isolation. Supposing susceptibility to have *remained constant* during that period we may take it that on an average infection occurred about half time, that is to say 1½ years before isolation occurred. If this is added to the average post isolation period of incubation, 2 years then the mean duration between infection and the first appearance of disease is 3½ years

Eight cases were infected before they were two years old, and of these infections possibly four but certainly one, took place during the first year of life

In Hawaii, Hollmann has recorded important data on similar lines. In the first place, he gives the following figures of male and female children to prove that the proportion of infections increases roughly with the duration of exposure (*Table XV*)

Table XV—EFFECT OF THE DURATION OF EXPOSURE

NUMBER	SEX	LENGTH OF EXPOSURE INFECTION IN YEARS	PERCENTAGE INFECTED
24	Female	Average of 4½	4
30	Male	Over 7	10
78	Female	Average 7½	15
22	Male	Over 10	32

Denny had previously shown the same thing in the Philippines, while the paper already referred to on the infection of children in the Culion settlement, confirms this point, for only 2 per cent of children under 5 years of age became lepers with certainty against 12 per cent of those from 5 to 8 years of age and 36·8 per cent of those who had lived with their leper parents for 10 to 13 years.

The ages at which the disease developed in cases of children who lived with leper parents are as follows —

Age in years	1	2	4	6	7	8	9	12	13	15	17
Number of cases	1	1	2	3	6	1	2	1	1	2	1

The average age of development, obtained by multiplying the ages by the number of cases at each age and dividing the total of these multiples by the number of cases is 8 years

If, once more we assume that approximately all ages of childhood are equally susceptible to infection—an assumption in favour of which we have the proved fact that the risk of infection is in direct proportion to the length of exposure—the most probable average age at which infection took place will be half the average duration of exposure, giving an incubation period of 4 years or closely approximate to the 3½ years of the Philippine series

In *Table XVI* we have compiled, from the data of 84 case collected from the literature by Rogers, particulars to illustrates

the probable duration of the incubation period These cases are divided into (*a*) cases with a record of the length of time between isolation and the first signs of the disease, and (*b*) cases with a record of the length of time between the beginning of contact with infectious cases and the first signs.

Seeing that the periods in the first series date from the cessation of exposure to infection and those in the second series date from the beginning of exposure to infection the average periods of these two series must indicate the approximate incubation period, supposing infection to take place on an average half way through the period of exposure

The average duration of the first series was 3 years 3 months 8 days, and of the second series 2 years 3 months but the difference was essentially due to the larger number of cases over five years duration in the first series, the effective isolation of which was more doubtful than that of those of five years and under as they occurred in endemic areas, and later exposures may have taken place. The average of the cases up to five years duration only was 2 years 1 month 16 days in the first series, and 2 years 3 months 2 days in the second series showing no appreciable difference, and that of the 77 cases up to five years of both series combined was 2 years 2 months 1 day

In any case, it is evident that this considerable series of cases goes to prove that the incubation is shorter than might be gathered from numerous statements in the literature on the subject and, allowing for the possibility that in some of those cases the source of infection may have been traced more readily on account of their comparatively short incubation period, the figure derived from their study is in fairly close accordance with those obtained from the series of children in the Hawaii and Culion settlements. We may therefore conclude that the average incubation period is from two to four years.

Cases in which the date of infection can be definitely fixed are comparatively few One of the best known of these is Marchoux s case of a young surgeon, called in by him to operate on a leper In the course of the operation he accidentally pricked his finger and leprosy developed some six or seven years later spreading from the pricked finger

One of us (E. M.) has seen a case of leprosy in a three months old child, and Ryrie records a macular eruption in a child of 48 days born of a mother with diffuse lepromatous lesions also three previous similar cases with lesions having a marked resemblance to tuberculoid leprides

Table XVI—Showing Various Calculations of the Incubation Periods

Definition of Cases	No. of Cases	Periods in Years					Average		
		year	–2 years	2–3 years	3–5 years	5 yr & over	Yr.	mth.	d.
a. Cases recording the periods from isolation to the appearance of signs	37	4 (10·8%)	7 (18·9%)	9 (24·3%)	7 (18·9%)	10 (27·1%)	3	3	8
b. Cases recording the periods from the first exposure to the appearance of signs	47	8 (17·0%)	16 (34·0%)	11 (23·4%)	6 (12·8%)	6 (12·8%)	2	3	0
Total Cases	84	12 (14·3%)	13 (27·4%)	20 (23·8%)	13 (15·5%)	16 (19·0%)	2	8	13

INCUBATION AND CLOSENESS OF CONTACT

The data have also been analysed from other points of view the results of which may be briefly mentioned. The question whether the rapidity of infection is influenced by the closeness of contact with an infected person is of great importance, and can best be answered by a further analysis of the series of 84 cases, bearing on the incubation period shown in *Table XVI* the results of which are given in *Table XVII* in which they are classed as due to (1) Inoculation (that is, cases where the point of inoculation was definitely known) (2) Sleeping in the same bed as a leper (3) House infections due to living in the same house with but not sleeping in the same bed as, the infected person and (4) Association of a less close nature with a leper including children infected from leper playmates, attendants on lepers in asylums, etc. Each class is divided into those in which the disease developed in less than three years after infection and those in which the period was three or more years In addition the 47 cases in which we know the duration of continued exposure to infection before the disease appeared, are shown separately from the total cases, and the average period of each class is worked out.

Table XVII—Showing the Relation of the Method of Infection to the Incubation Period

Method of Infection	Total—84 Cases				47 Cases with Recorded Length of Exposure to Infection				Average		
	Under 3 years		3 years and over		Under 3 years		3 years and over				
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	Yrs.	mths.	days
Inoculation	4	100·0	0	0·0	1	100·0	0	0·0	0	6	0
Bed infections	20	76·9	9	23·1	23	85·2	4	14·8	1	8	7
House infections	15	65·2	8	34·8	9	75·0	3	25·0	2	10	0
Association only	6	33·3	12	66·7	2	28·6	5	71·4	4	11	17
Total	55	—	29	—	35	—	12	—		—	

The figures are very instructive, for of the few inoculation cases, all had incubation periods of under 3 years, in three of them the periods being only 5 months, 6 months, and 1½ years respectively In 77 per cent of the bed infections, and 65 per cent of the house infections, the disease appeared within less than 3 years, but in only 33 per cent of those with close association was the period under 3 years.

Still more striking are the figures of the 47 cases in which the period between first exposure to infection and first signs of the disease was recorded. They are given in the right hand side of the table, and show 85 per cent of the bed cases and 75 per cent of the house ones with periods of under 3 years, against only 28 per cent of the less close association cases. The duration of the incubation period in these classes brings out this essential point still more clearly by showing a period of 6 months in the one inoculation case and an average of 1 year 8 months in the bed cases, 2 years 10 months in the house cases as contrasted with an incubation period of almost 5 years in those association cases which had a contact period of less than 1 year

This indicates that the difference is not so much in the nature of the infection as in the frequency of the opportunities of lepra bacilli from the diseased gaining access to the healthy as the result of the closeness and continuity of the contact between them. The longer periods between exposure to infection and first signs of the disease in association cases are due to fewer opportunities of personal contact with the infecting persons or agents, and hence fewer chances of implanting the infecting organism in the tissues, with consequently later infection and development of the disease All this indicates that the incubation period in the great majority of cases is even shorter than the figures in the table indicate and probably only exceptionally exceeds two or three years

On the other hand Lampe found in Java that 47 out of 55 lepers (80 per cent) had no other known case of leprosy in their families or households, and had therefore presumably been infected from without their families This may depend on special pre cautions being taken inside but not outside the house, or on the distribution of susceptible subjects

In the census report of India for 1921 the number of lepers reported as under 1 year of age is 68 from 1 to 2 years of age 99, from 2 to 3 years of age 159 This makes the total number of lepers under 3 years of age 326 or 0·4 per cent of the total recorded at all ages If the diagnosis in even a fraction of these cases was correct, we have additional proof of the possibility of a short incubation period in leprosy

DELAY IN RECOGNITION OF DISEASE

The apparently prolonged incubation period recorded in many cases is probably due to the insidious way in which the disease often develops, as patients may suffer from leprosy for many years without noticing the early symptoms Three cases, which

came under the observation of one of us well illustrate this point

1 A patient had complained of pains in the lower limb for 10 years, and had been treated during that period by competent medical men for lymphangitis without the true nature of his malady being suspected. On examination a thickened tender nerve was found in the place of the supposed lymphangitis and abundant lepra bacilli were found in lesions scattered all over the body

2 A student had two depigmented anæsthetic patches for 9 years, during which period these were the only signs of the disease At the end of this time the patient came for examination, as the patches were beginning to grow larger Had the patient's skin contained less pigment, or had he been less observant, the incubation period might have appeared to be 9 years longer

3 In a third case the patient had noticed two small, slightly depigmented anæsthetic patches, each about an inch in diameter which had remained in the same state for 22 years without any other signs of leprosy being noticed. On examinaton, thickening of the right great auricular nerve was found confirming the diagnosis of leprosy

These three are typical of many other cases, and illustrate the fact that leprosy may slowly develop and spread through the body for many years before it is noticed by the patient or diagnosed by the doctor

The apparent incubation period tends to be lengthened when cases occur in non-endemic areas or in communities among whom the disease is uncommon, as they are less acquainted with the early signs, and many mistake them for the signs of other diseases. As depigmentation is an easily recognized sign which often precedes by a long period all other signs of the disease it follows that in fair-skinned people the diagnosis may be delayed and when the time of infection can be traced the apparent incubation period may be lengthened

CONCLUSIONS

1 There are few cases on record which allow the incubation period of leprosy to be definitely fixed but in the children at the Culion settlement the disease appeared on an average two years after their separation from their leper parents and, if half the average period of their previous exposure to infection is added the incubation period would average 3½ years and vary between 5½ months and 4 years

2 An analysis of 84 recorded cases shows that in 81 per cent the disease developed within less than 5 years after exposure to infection while in most of the remainder there had been repeated opportunities of infection subsequent to their first removal from contact so that they afford no proof of incubation periods longer than 5 years. And although there are cases on record of long periods between leaving an endemic area and the development of the symptoms they are very rare, while it is very difficult to exclude the possibility of slight lesions which may have existed, unrecognized, long before a diagnosis of leprosy was made. If such doubtful cases are omitted the average period betwe exposure to infection and the development of the disease is onl 2 years 2 months

3 There is a direct relationship between the closeness of contac with the diseased and the early development of symptoms, as shown in the last column of *Table XVII* The apparently longer incubation periods are therefore more likely to be the result of milder infections due to less opportunity for inoculation. The true incubation period is comparatively short it probably only exceptionally exceeds 3 years, and is usually not more than 2 years, or less than has hitherto been commonly supposed.

4. The length of incubation is considerably affected by the general health and habits of the patient, and the climate in which he lives It is frequently noticed that the first signs of leprosy appear after or during the course of acute or chronic diseases such as dysentery enteric fever kala azar syphilis, malaria, influenza, etc The probability is that in these cases, but for the occurrence of such a predisposing disease, the onset would have been delayed if not averted altogether

THE ONSET OF LEPROSY

PRELIMINARY CONSIDERATIONS

There are certain features peculiar to leprosy which it is well to consider first if the onset and course of the disease are to be understood.

One of the chief characteristics of leprosy as compared with other diseases is its low toxicity Enormous numbers of bacilli may be present in the body with few or no toxic signs. Also the local inflammatory reaction to lepra bacilli varies tremendously in different types of cases. These points are best illustrated by comparing two extreme types of case as they may first present themselves for diagnosis In one the disease is confined to a small skin area and the main nerve which supplies this area with

sensory branches. In this main nerve there is acute inflammatory swelling causing considerable local pain and producing trophic sensory and other disturbances in the parts it supplies. On careful bacteriological examination only a few bacilli are found with difficulty In the other case almost the whole body is affected A smear taken from any part of the skin reveals numerous bacilli Yet the condition causes the patient no pain or discomfort he is able to go about and do his work the nerves are not noticeably thickened or tender and the skin appears normal and free from nodules or other lesions when subjected to anything but the most careful inspection. Between these two extremes we have all manner of subtypes and subgrades.

It will thus be easily understood that an infection, which is capable of so completely invading and infiltrating the system without causing either noticeable clinical signs or any considerable feeling of malaise to the patient, can at times be exceedingly insidious in its onset and escape detection for a considerable time.

On the other hand, at any stage in the invasion of the body there may be a sudden exanthematous reaction accompanied sometimes by fever and other general symptoms lesions suddenly becoming visible as congested skin nodules or macules which may disappear again after a short time or may remain permanently visible. This sudden appearance or congestion of lesions which is often a sequel of some debilitating condition is described later under LEPRA REACTION (p. 187) Not infrequently this reaction calls the patient's first attention to the disease which has been spreading through the body insidiously for a considerable time without attracting notice

ONSET

The onset of leprosy may be acute or chronic, varying according to the resistance of the patient and of the tissues of the body

1 **Chronic Onset.**—The onset may be so gradual and insidious that the disease may have advanced to a considerable extent before any abnormality is evident. The first signs are often noticed by the doctor when the patient consults him about some other complaint. Tenderness, tingling or thickening of a nerve, an area of anæsthesia with or without any change in the appearance of the skin, absence of pain when the fingers are burnt with a cigarette, formication, tingling or numbness in the extremities, these are in the most chronic cases among the earliest indications which draw the patient's attention

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fewer large infiltrations or nodules or diffuse lepromatous changes of moderate degree lesions of the nasal mucous membrane are frequently present.

Lepromatous 3 (L3).—Advanced lepromatous cases with numerous and extensive or very marked lepromatous lesions, which may vary in their stage of development or retrogression lesions of the nasal mucous membrane are almost always present.

Neural 1 (N1).—Slight neural (*a*) cases with from one to several small macules, or a proportionately smaller number of larger macules, whether flat or elevated, without indications of polyneuritic changes or (*b*) cases presenting only polyneuritic changes of slight degree—disturbances of peripheral sensation affecting one or two extremities, not of marked extent, with only minor trophic disturbances muscular atrophy or paresis if any or (*c*) cases showing combinations of macular and polyneuritic manifestations in equivalent degree of total affection.

Neural 2 (N2).—Moderately advanced neural (*a*) cases with fairly numerous or large macules, or wide distribution, without evidence of polyneuritic changes or with such manifestations of fairly slight degree or (*b*) cases presenting only polyneuritic changes of moderate degree—peripheral anæsthesia of considerable extent if affecting only one extremity of less extent if affecting more than one—and moderate trophic changes, atrophy and paralyses including beginning contractures if of limited extent or (*c*) cases showing combinations of equivalent total degree.

Neural 3 (N3)—Advanced and neural (*a*) cases with very numerous or very extensive macular lesions of the more marked kinds with polyneuritic changes or (*b*) cases presenting only advanced polyneuritic changes such as extensive peripheral anæsthesia and more or less marked motor and trophic disturbances trophic ulcers, and mutilations or (*c*) cases showing combinations of equivalent total degree.

* * * * *

While this classification describes only two main types of leprosy it is quite usual to find both types present in one patient, and the case is then said to be a mixed one. The degree of advancement of each type is indicated by the appropriate symbol, giving the more severe lepromatous type the precedence, whichever form may have first appeared, e.g. L3–N2 or L1–N3

Cases may also be subclassified according to the kind of lesions Lepromatous cases may show neither macules nor nodules but a

widespread inconspicuous type of lesion These may be indicated by a d for diffuse, thus, Ld2 Neural cases may be subclassified according as the lesions are polyneuritic (Na) simple macules (Ns) tuberculoid macules (Nt) or a combination of any of these, e.g., Nat2 The figures indicating the degree of disease are added after these letters

The Cairo Congress also suggested special symbols to indicate additional important information Thus, the bacteriological finding may be shown by adding the symbol + or — In a mixed case the type of leprosy which appeared first may be indicated by an inclined stroke placed above the appropriate letter thus L2–N 1 would mean that the case was primarily of the neural type. Secondary neural cases may be indicated by a double stroke (N″)

A description of the various forms of lesions mentioned above is given in the following chapter

Relative Frequency of the Types —Very varying reports are received from different countries and leprosaria as to the relative frequency of the two main types. It is only recently that a clear and definite method of classification has been generally accepted, and in time uniform and comparable reports should become available. The relative frequency of types varies according to the thoroughness of the survey made. Those seeking voluntary admission to institutions are not a reliable cross-section of the leprous population and still less those collected under compulsion. The methods necessary for accurate survey are described in Chapter VIII and Appendix IV (*See also* pp 122 135, 177)

In most parts of India and Africa and elsewhere the neural type preponderates, forming from 55 to 90 per cent of the whole The collection of accurate statistics of types and subtypes, and inquiry into the reasons for variation in different places, should throw considerable light on the nature of leprosy

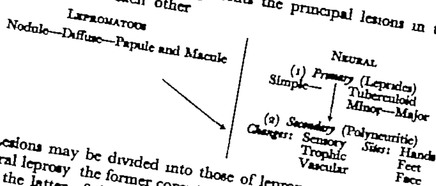
CHAPTER XII

CLINICAL SIGNS AND PATHOLOGY OF THE LESIONS

The clinical appearance is so much bound up with the pathology of lesions that we have considered it advisable to describe them together

LESIONS OF THE SKIN AND MUCOUS MEMBRANES

The following scheme represents the principal lesions in their relationship to each other



Lesions may be divided into those of lepromatous and those of neural leprosy the former consisting chiefly of the more malignant, and the latter of the more benign type The term leproma is based upon the histological appearance of a distinct type of lesion but without examining sections, it can generally be recognized by examining a biopsy smear because of the comparatively large number of bacilli present and in typical cases the condition can also be recognized by its clinical appearance.

LESIONS IN LEPROMATOUS LEPROSY

The shape and extent of lepromatous lesions varies considerably The earliest recognized lesions are generally multiple and obviously the result of bacillary metastasis from some unknown reservoir inside the body The more acute the process the more numerous the foci The local reaction to bacillary emboli in the skin varies considerably In many cases it passes without notice, or an evanescent rash may appear and disappear indicating the infection of skin areas in which later widespread infiltration is found to

have taken place extending from the original focus without immediate clinical signs.

Lepromatous lesions develop in different ways, but most commonly papules or macules (sometimes known as prelepromatous macules) appear first these increase in size until they converge and form a diffuse infiltration later nodules may appear on the diffuse infiltration.

Papules are smaller than macules not larger than a split pea in size. They occur in both the main types of leprosy

Macules are more or less circular or elliptical patches coloured differently from the surrounding skin. The term is most commonly applied to patches found in the lepromatous type, but the leprides of the neural type are also less correctly termed macules The former are as a rule smaller more numerous and more symmetrically placed than the latter They affect chiefly the superficial layers and do not cause much thickening of the skin. They are raised more at the centre and fade at the margin into the surrounding skin In fair skins they appear chiefly as red patches, while in dark skins hypopigmentation is also a distinctive sign Macules vary in size, they may begin small and gradually enlarge until they coalesce with each other thus unitedly affecting large areas of skin. Finding of bacilli in biopsy smears and the absence of a raised margin are features which distinguish lepromatous macules from leprides (*Figs* 11 40, 54.)

Diffuse Infiltration of the skin is brought about either by the coalescing of macules or by the expansion and joining together of invisible, or at least unnoticed foci. In both cases the process is the same, but in the latter the cutaneous reaction to the infection is so slight that macules do not appear It is only later when the deeper layers of the cutis have become involved and the infiltrated skin becomes thicker that clinical signs become noticeable (*see Fig* 16) and the skin develops a swollen, glossy and corrugated appearance with the skin markings exaggerated.

Nodules are round lepromatous elevations of skin of limited size. They may be temporary and evanescent, or permanent They may be soft and highly vascular or hard and fibrous. The skin markings may be entirely flattened out. What determines the formation of a nodule it is difficult to say It may be formed at the site of a bacillary embolus either in normal skin or more commonly in skin already infiltrated with leproma. It seems reasonable to suppose that the location may be determined by a previous injury causing local lowered resistance of the tissues, especially as nodules are commonest on exposed parts most liable

to injury such as the hands and face (see Figs 13–18 24, 34 87)

Histology of Leproma (*see Figs* 77–79) —The chief distinguishing feature is the lepra cell Thus cell, of macrophage origin, is associated with tolerance to lepra bacilli, considerable numbers of which it may contain, the bacilli apparently multiplying in the cytoplasm until they finally may destroy the cell. The lepra cell was first described by Virchow as vacuolated, the vacuoles giving it a foamy appearance But the so-called vacuoles stain black with osmic acid and therefore contain some fatty or lipoid substance. Mitsuda finds that staining with Sudan III makes this substance show up both microscopically and to the naked eye, so that obscure lesions can be recognized he considers that there is strong evidence that this lipoid substance is the result of bacillary degeneration, and is particularly prominent in resolving lesions Besides lepra cells there is an infiltration of small, round lymphocyte like cells, and also mast cells

In a new lesion, or in the spreading margin of an older lesion, bacillary invasion and cellular infiltration are found chiefly round the capillaries of the subpapillary plexus and its papillary branches. Later the process may spread deeper along the vessels surrounding the hair follicles and sweat-ducts while at the same time extending into the interfollicular spaces until the whole of the corium and sometimes even the subcutaneous tissue become infiltrated New fibrous tissue is laid down in connexion with the cellular infiltration, the amount varying with the intensity and the chronicity of the process. In some cases the infection is massive, the leproma being composed chiefly of lepra cells crammed with bacilli In older lesions where contraction of fibrous tissue has taken place the texture is hard and non vascular While the infection is chiefly confined to the cutis, bacilli, sing ly or in masses may be found in the substance and even on the surface of the cuticle. The disease in the cutis has also an indirec effect on the epithelial structures The papillæ and interpapillary spaces may be flattened out leading to considerable thinning of the cuticle. In sections of marked lesions the most superficial part of the cutis corresponding to the papillary layer may be found to be slightly œdematous and to contain only fibrous tissue with few cells and bacilli. The hair follicles and sweat-glands may also be destroyed.

The histological appearance of lepromatous lesions of the mucous membranes in the nose, mouth, and upper respiratory passages is very similar to that in the skin. The actual lesions are described in the regional section (Chapter XIII)

LESIONS IN NEURAL LEPROSY

These consist of leprides (a term applied to macules of the neural type) and polyneuritic lesions caused by involvement of large nerves.

Leprides take the form of simple, minor tuberculoid and major tuberculoid macules (*see Fig* 11) They are characterized in greater or lesser degree by the following changes —

1 *Anidrosis* (*see Fig* 50) which may be preceded by hyper drosis this is one of the first signs to manifest itself (p 221)

2 *Hypopigmentation* this is much more commonly noticed as the first sign in skins which contain a large amount of pigment. It is not a complete depigmentation such as is found in leucoderma but is partial It is caused by interference with the function of the melanoblasts.

3 *Hyperesthesia* the area of the lesion is tender to touch, and painful sensation will sometimes be elicited by tapping the nerves which form the sensory supply of the lesion, showing that the infection has begun to spread up these nerves.

4. *Anesthesia* follows hyperesthesia, though the latter may not always be noticed. If anesthesia to light touch is marked it is generally found that deep anesthesia and absence of pain, as tested by the insertion of a needle or pin into the skin are also present. Thermal sensation also is absent, the patient being unable to distinguish when the affected area is touched with a test tube containing hot or cold water (p 215)

5 *Parakeratosis and hyperkeratosis* The former of these is recog nized clinically by a certain change in the horny layer of the epithelium (*Fig* 45) There is a shiny appearance of the surface of the skin, often accompanied by the appearance of scales. The stratum corneum is not of its usual smooth, elastic consistence the cells retain their nuclei and adhere to one another so that they are not shed individually but as scaly masses. Hyperkeratosis is best seen on the palms of the hands and soles of the feet, where the epithelium becomes abnormally thick and is apt to crack, forming the most superficial variety of perforating ulcer on the soles of the feet.

6 *Affection of Hair and Nails* The hair follicles are also affected the hairs become soft and thick, and break off at their point of emergence from the surface of the skin. The broken end may become club-shaped and, as growth still continues inside the hair becomes bent up inside the follicle. Similar changes also take place in the nails which become thickened and curve over the ends of the fingers in a manner similar to bird s claws (*see also* p 198)

7 *Vascular changes* resulting in congestion and erythema, sometimes found throughout the whole lesion and sometimes confined to the margin.

8 *Bacteriological findings* are generally negative, or bacilli if found are only in small numbers

In the **Simple Macular Lepride** (abbreviation Ns) there is little or no palpable thickening of the skin. There is a narrow reddish margin slightly raised and irregular (amoeboid) in shape. The intramarginal area is not raised it shows, especially in dark skins a greater or less degree of hypopigmentation. In fair skins a good light may be necessary to observe these characteristics. The surface is smooth, not pebbled as in the tuberculoid lesion. When a simple macule becomes inactive the margin becomes flat and loses its redness and amoeboid shape but the whole area retains its loss of pigment and a slight degree of anaesthesia. A single lepride may spread centrifugally till it covers a large area, or the process may be accelerated by the coalescing of several neighbouring lesions (*See Figs* 39–41)

Tuberculoid Lesions (abbreviation Nt) are so called from their histological resemblance to those of the more chronic type in tuberculosis They are divided into minor and major according to the degree of their characteristics.

Minor Tuberculoid Lesions are leprides which vary considerably in size and shape, but they all have a characteristic appearance of elevation above the level of the surrounding skin. The surface is usually pebbled in appearance due to the underlying follicular nature of the tuberculoid process. The smallest lesion is a papule or small macule which tends to extend by irregular centrifugal spread As the patch enlarges it generally flattens out at the centre, leaving a raised active pebbled margin, much broader than that of the simple lepride, and a smoother atrophic central region in which active disease has died out. The centre retains its loss of sensation and, especially in dark skins, its partial loss of pigment, though these are often regained to a certain extent in course of time. Lesions may be single but when multiple tend to coalesce and cover large areas of the body (*Figs* 45 46 47) Occasionally there is only slight elevation but the pebbling distinguishes from the simple lepride. The elevation of the skin surface may take the form of bands or areas which may be continuous or discontinuous even to the point of producing isolated papules. Occasionally the process is relatively deep in the dermis, in which case the surface may be relatively smooth, and the appearance may therefore approach that of some of the major tuberculoid

lesions, but the degree of the condition is less than in that form (*see Figs* 37 43 67)

The **Major Tuberculoid Lesion** is more grossly elevated than the minor It also tends to be more acute in its onset and sudden in appearance. It invades the deeper layers of the cutis and even the subcutaneous tissue, and when the skin is picked up between the finger and thumb it gives the feeling of great thickening and hardness. Clinically there are two varieties of major tuberculoid In the first and commoner variety the lesions are asymmetrical in distribution and for the most part large in size. There may be a single lesion (*Figs* 52 53 65) or multiple lesions (*Figs* 54, 55, 57) The affected area may be thickened throughout, or only at the margin It has a red inflammatory appearance, sometimes resembling erysipelas The surface may be smooth and glistening scaley or papulated especially at the margin. Small pioneer papules may appear beyond the margin.

If the condition is very acute there may be subcutaneous liquefaction undermining the affected area and thin purulent material can be removed by incision or may ulcerate its way out. Sometimes extensive ulceration occurs followed by delayed healing leaving behind deep scars (*Figs* 53 56) In some cases the sensory nerves supplying the area are conspicuously thickened (*Fig* 65) In the less acute cases the original lesions are small and gradually increase in size (*Fig* 54) In the more acute the severe tissue reaction seems to prevent further spread and favour spontaneous resolution.

The second and rarer variety of major tuberculoid takes the form of widely scattered small lesions with or without larger lesions (*Figs* 55 57) it may closely resemble psoriasis in outward appearance (*Fig* 58) It generally appears with an acute inflammatory onset accompanied by febrile symptoms which may be severe and last for several days or weeks. The lesions are covered with fine scales, and in the most acute cases extensive ulceration occurs producing what has been termed lazarine leprosy

In both varieties lepra bacilli are found sometimes in fairly large numbers, but seldom if ever in the clumps characteristic of the lepromatous type. Major tuberculoid leprides are sometimes mistaken for lesions of the lepromatous type the chief distinguishing features are (1) Their sharp demarkation from the healthy surrounding skin, though this must not be confused with the nodular form surrounded by lepromatous infiltration shown in *Fig* 18 (2) Their asymmetrical distribution (3) The

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In the **Simple Macular Lepride** (abbreviation Ns) there is little or no palpable thickening of the skin There is a narrow reddish margin slightly raised and irregular (amoeboid) in shape. The intramarginal area is not raised it shows, especially in dark skins a greater or less degree of hypopigmentation In fair skins a good light may be necessary to observe these characteristics. The surface is smooth, not pebbled as in the tuberculoid lesion. When a simple macule becomes inactive the margin becomes flat and loses its redness and amoeboid shape, but the whole area retains its loss of pigment and a slight degree of anaesthesia. A single lepride may spread centrifugally till it covers a large area, or the process may be accelerated by the coalescing of several neighbouring lesions (*See Figs* 39–41)

Tuberculoid Lesions (abbreviation Nt) are so called from their histological resemblance to those of the more chronic type in tuberculosis. They are divided into minor and major according to the degree of their characteristics

Minor Tuberculoid Lesions are leprides which vary considerably in size and shape, but they all have a characteristic appearance of elevation above the level of the surrounding skin The surface is usually pebbled in appearance due to the underlying follicular nature of the tuberculoid process. The smallest lesion is a papule or small macule which tends to extend by irregular centrifugal spread As the patch enlarges it generally flattens out at the centre, leaving a raised active pebbled margin, much broader than that of the simple lepride, and a smoother atrophic central region in which active disease has died out. The centre retains its loss of sensation and, especially in dark skins, its partial loss of pigment, though these are often regained to a certain extent in course of time. Lesions may be single, but when multiple tend to coalesce and cover large areas of the body (*Figs* 45, 46 47) Occasionally there is only slight elevation but the pebbling distinguishes from the simple lepride. The elevation of the skin surface may take the form of bands or areas which may be continuous or discontinuous even to the point of producing isolated papules Occasionally the process is relatively deep in the dermis, in which case the surface may be relatively smooth, and the appearance may therefore approach that of some of the major tuberculoid

lesions, but the degree of the condition is less than in that form (see Figs 37 43 67)

The **Major Tuberculoid Lesion** is more grossly elevated than the minor It also tends to be more acute in its onset and sudden in appearance. It invades the deeper layers of the cutis and even the subcutaneous tissue, and when the skin is picked up between the finger and thumb it gives the feeling of great thickening and hardness Clinically there are two varieties of major tuberculoid In the first and commoner variety the lesions are asymmetrical in distribution and for the most part large in size There may be a single lesion (*Figs* 52 53 65) or multiple lesions (*Figs* 54, 55, 57) The affected area may be thickened throughout, or only at the margin It has a red inflammatory appearance, sometimes resembling erysipelas The surface may be smooth and glistening, scaley or papulated especially at the margin Small pioneer papules may appear beyond the margin

If the condition is very acute there may be subcutaneous liquefaction undermining the affected area and thin purulent material can be removed by incision or may ulcerate its way out. Sometimes extensive ulceration occurs followed by delayed healing leaving behind deep scars (*Figs* 53 56) In some cases the sensory nerves supplying the area are conspicuously thickened (*Fig* 65) In the less acute cases the original lesions are small and gradually increase in size (*Fig* 54) In the more acute the severe tissue reaction seems to prevent further spread and favour spontaneous resolution.

The second and rarer variety of major tuberculoid takes the form of widely scattered small lesions with or without larger lesions (*Figs* 55, 57) it may closely resemble psoriasis in outward appearance (*Fig* 58) It generally appears with an acute inflammatory onset accompanied by febrile symptoms which may be severe and last for several days or weeks. The lesions are covered with fine scales, and in the most acute cases extensive ulceration occurs producing what has been termed lazarine leprosy

In both varieties lepra bacilli are found, sometimes in fairly large numbers but seldom if ever in the clumps characteristic of the lepromatous type. Major tuberculoid leprides are sometimes mistaken for lesions of the lepromatous type the chief distinguishing features are (1) Their sharp demarkation from the healthy surrounding skin though this must not be confused with the nodular form surrounded by lepromatous infiltration shown in *Fig* 18 (2) Their asymmetrical distribution (3) The

histological findings as shown below (4) The lepromin *test* (p 48) (5) The tendency towards disappearance of bacilli and spontaneous resolution which is in direct proportion to the acuteness of onset. As in the striking case illustrated in *Figs* 55 and 56 widespread lesions containing abundant bacilli *may entirely resolve spontaneously within* a comparatively short time leaving only scars and sometimes resulting in a permanent cure.

It is very important to recognize the protean appearances of major tuberculoid lesions, as even in cases *with an alarming onset* a favourable prognosis can be made.

Intermediate Cases —Not infrequently cases are found which seem to lie in an intermediate position between those with major tuberculoid lesions and frank lepromatous cases, characteristics of both types being found. While the prognosis is distinctly worse than in the former it tends to be better than in the latter It is particularly during the inflammatory reaction phase that the distinction tends to be blurred, but it becomes more clear as the reaction subsides. Differentiation between simple leprides and lepromatous macules may also occasionally be difficult, especially if the margin is ill-defined The finding of bacilli is the chief distinguishing feature.

Histology of Tuberculoid Lesions (*Figs* 78 80) —As the lepra cell is the chief characteristic of leproma, so the epithelioid cell is distinctive of the tuberculoid lesion not only in the skin but also in nerves affected by the neural type of leprosy Unlike the former this cell seldom if ever is found to contain lepra bacilli Indeed except in the acute inflammatory major tuberculoid, bacilli are usually difficult or impossible to find in this type of lesion, though in associated thickened nerve branches they are often easier to locate. Another characteristic is the multinucleated cell, the so-called giant cell of Langhans very occasionally one or more bacilli may be found in connexion with these cells. Giant cells may be small or of considerable size they are found in both skin and nerve tissue. Surrounding these elements are large numbers of small lymphocyte-like cells. In typical tuberculoid lesions the cellular elements tend to be arranged in dense cords which in section appear like tubercles These cellular cords are formed round the vessels and nerves of the papillary and subcutaneous plexuses and the vessels and nerves which connect these two plexuses. They extend likewise along capillary branches into the papillæ, which become flattened out with thinning of the epidermis The process may extend along the subcutaneous plexus to some distance

beyond an apparent lesion, and then reach the surface by spreading up along a hair follicle, causing an isolated papule like thickening of the skin surface separated from the parent lesion This dense cord like cellular formation is generally in marked contrast to that seen at the spreading margin of a lepromatous lesion in which the arrangement is much more loose and scattered. According to Wade, the activity of lesions seems to be indicated by abundance of *typical* epithelioid cells, while atypical epithelioid cells and few giant cells indicate relative inactivity Vacuolated epithelioid cells have been described in atypical tuberculoid leprides. In the major tuberculoid the inflammatory process may be so acute that necrosis of the skin surface takes place, and ulceration The *histology of the simple macule* is similar to that of the minor tuberculoid except that the infiltration is more confined to the superficial layers of the cutis, and the cellular elements characteristic of the tuberculoid (epithelioid and giant cells) are less marked the chief element being the small round cell.

Both hair follicles and sweat organs are impaired or destroyed by the surrounding infiltration.

Secondary or Polyneuritic Lesions (abbreviation Na) occur in the distal parts of the limbs and are the result of involvement of peripheral nerve-trunks. As a rule, though perhaps not invariably infection reaches the nerve trunks by passing up sensory nerves from pre-existing lesions in the skin (*see Figs* 65 67 68 71) The inflammatory process set up in the affected trunks causes in their distribution sensory changes, and such trophic impairments as anhydrosis, glossy skin, keratosis, perforating ulcer softening and necrosis of bone, neuropathic joint lesions, paralyses and atrophies of the small muscles of the hands and feet, and mutilations in the extremities. There are also secondary changes in the muscles of the face

For detailed descriptions of polyneuritic lesions see the *Regional Consideration of Lesions* in Chapter XIII

Polyneuritic lesions are thus secondary to the lepromatous lesions and leprides described above. Unlike the latter they are caused by the presence of bacilli not in the lesions themselves but in their supplying nerves.

In a neural case all active leprides large and small, are of one form and closely resemble each other it is common, however for polyneuritic lesions to coexist with macules of all types. In what is known as mixed leprosy they coexist with lepromatous lesions. This may be due to an initial neural case degenerating into a lepromatous one, in which the earlier polyneuritic signs

persist, or polyneuritic signs may come first into evidence in the resolution stage of a primarily lepromatous case (*see* p 204)

Lesions of the Peripheral Nerves.—Affected nerve-trunks and their branches often show more or less enlargement and tenderness The thickening of the trunks is related to their position and liability to mechanical injuries Thus the ulnar nerve is most commonly affected at the elbow while the radial nerve which is well protected at the elbow is more involved in the superficial part of its course in the forearm. Thickening of the branches is generally in relation to leprides of the neural type.

The histopathology of nerve lesions corresponds to that of the skin in each type. Thus in advanced cases of the lepromatous type bacilli are more abundant and there is lepra-cell infiltration, with the formation of fine fibrous tissue chiefly in the endoneurium This fibrous tissue may contract later and block or destroy the nerve fibres In some lepromatous cases bacilli may be present in large numbers with little sign of cellular reaction (*see Fig* 79) In this type there is therefore comparatively little interference with the functions of the nerves, and sensory motor and trophic changes are slight.

In the neural type the bacilli are fewer in number though as a rule it is easier to find them in the nerves than in the skin. The cellular reaction tends to be much more intense, and epithelioid and giant cells are present in greater or lesser numbers, surrounded by small round cells. There is thus much more interference with nerve function. Cellular infiltration generally begins round the smaller vessels, which may be considerably congested it affects certain nerve bundles or groups of bundles. The cellular elements may form a solid cord surrounded by the displaced nerve fibres The inflammation may be so acute that necrosis and caseation take place and a cold abscess may form inside the nerve Thickened nerve trunks may become surrounded by a dense fibrous sheath which may later cause constriction (*See Figs* 65 67–71)

Leprous nerve abscess is a rare condition in some endemic countries, but it is not uncommon in some parts of India. It is almost always associated with the neural type, though it has been reported in a few lepromatous cases. It appears to be associated with injury and occurs only in superficial nerves, either main trunks or sensory branches. The following are among the nerves most commonly affected with this condition ulnar median cutaneous of the forearm, great auricular sural. The abscess when small may be central and spindle shaped but as it enlarges, especially

in a nerve trunk it more commonly lies under the thickened capsule forming a balloon like projection When evacuated it is found to contain white pus similar to that of a gland abscess in tuberculosis. Round the inside of the thickened capsule may be a certain amount of caseous material Examination of the pus may or may not reveal acid fast bacilli (*See Figs* 69, 71)

Paths of Nerve Infection —While peripheral nerves may become infected directly through the blood-stream especially in lepromatous cases, the more common path of infection in the neural type is from the skin, the bacilli passing up the sensory branches from a macule or other cutaneous lesion The local sensory branches may become thickened and tender or the infection may pass up the smaller branches into a mixed nerve trunk without affecting them. Two main nerves affording sensory supply to skin covered by a single macule may be the only ones affected in the body The infection may even travel up from the skin without there being any visible macule or other skin lesion (*See Fig* 12)

FACTORS DETERMINING THE TYPE OF LEPROSY

On comparing lesions of the lepromatous with those of the neural type of leprosy it is clear that there is in the former a much greater degree of tolerance to *B lepra* than in the latter In lepromatous lesions the lepra cell harbours the bacillus and permits it to multiply in its cytoplasm while, considering the comparatively large number of bacilli present the leproma shows at its spreading margin a meagre tissue response, the cellular infiltration being loose and scattered (*see Fig* 77)

The tuberculoid lesion of the neural type gives a very different histological picture (*see Fig* 80) At the spreading margin the few bacilli present call forth a strong tissue response producing a dense, clear-cut, cellular mass. The epithelioid and giant cells are typical here as in tuberculosis and other diseases of strong resistance to the invading organism

The fact that in any one representative case of either type all the lesions present resemble each other shows that the resistance is constitutional and not confined only to certain parts of the skin What is the factor which determines the type of leprosy? There is no evidence that the two types are caused by different strains of bacilli. Nor will the general health of the patient, exceedingly important though it is, account for the type of disease as weak debilitated patients are often found with the neural type, and apparently healthy individuals succumb to the lepromatous The

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probability is that the majority of subjects are born with strong natural resistance to leprosy Even when subjected to infection they generally do not develop clinically recognizable signs, or the lesions are slight and abortive When the disease does develop it is of the milder neural type There is, however a minority of subjects, perhaps one in ten, who are particularly susceptible in them even slight contact with leprosy may be sufficient to establish the disease which tends to develop into the severe lepromatous form.

Under unfavourable conditions which interfere with the general health of the patient, the neural not infrequently degenerates into the lepromatous type (*see Figs* 36 38) On the other hand, as the lepromatous type dies out, either spontaneously or as the result of treatment, the neural type with anæsthetic acroteric lesions tends to take its place (*See* IMMUNITY p 154)

Apart altogether from transformation of the one main type into the other there is much room for advance and retrogression within the bounds of each type, these being chiefly governed by the general health of the patient, debility tending to cause increase, and improved health amelioration, of the disease.

The question arises Why should high resistance determine the neural, and low resistance the lepromatous, type of leprosy? In both types the nerves become infected Indeed the lepromatous shows a greater concentration of bacilli than the neural type in both nerves and skin. But in the latter type the cellular reaction to the comparatively few bacilli is much greater and quite out of proportion to their small number and it is this intense cellular reaction and infiltration which causes thickening of nerves, pressure on their fibres, and the sensory trophic and other characteristics of the neural type. Later as the thickening diminishes, the contraction of newly formed connective tissue inside the nerves may continue this pressure on the fibres

Symmetry of Lesions.—This is more noticeable in lepromatous than in neural lesions. In the former bacillæmia is more frequent and more marked, and embolic bacilli are more likely to survive and grow in the less resistant tissue of this type. The whole skin may become infiltrated diffusely and in such cases the appearance of symmetrical lesions may depend chiefly on nodules and other conspicuous thickenings of the skin which tend to concentrate at the sites most liable to injury or friction, such as the ears, the brow the knees, elbows, hands, and feet.

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occasional and sparser in the blood-stream and less likely to survive in the more resistant tissues. When leprides cover large areas it is generally the result of gradually extending lesions from comparatively few foci (*see Figs* 39, 40 45, 54) and the chance of bilateral symmetry is therefore considerably less Polyneuritic lesions of the acroteric anaesthetic type, which appear secondarily in the course of the resolution of severe lepromatous cases, tend to be symmetrical affecting all limbs but those which appear as primary lesions more often affect only one foot or one hand When there is doubt whether lesions are tuberculoid or lepromatous, symmetry is an important determining factor

LEPRA REACTION

The usual course of leprosy of whatever type is chronic, slow and insidious. In contrast to this is the condition known as lepra reaction acute exacerbation activation or sometimes lepra fever Two types of lepra reaction must be distinguished that associated with lepromatous leprosy and that occurring in neural leprosy and chiefly associated with major tuberculoid lesions

Reaction in the Lepromatous Type.—This may be acute or subacute. The *acute condition* is usually accompanied by more or less severe febrile and other constitutional symptoms. Some or all of the existing clinical lesions show sudden swelling and vascular engorgement New lesions appear as nodules or macules and in severe cases there may be marked oedematous swelling in surrounding parts (*see Fig* 22) Cutaneous and subcutaneous nodules may form pustules or abscesses which break down and discharge pus rich in lepra bacilli. These bacilli are either free or contained in pus cells chiefly of the polymorphonuclear type. In sever cases, as the reaction subsides, the lesions remain covered with thick black epithelium, which gradually desquamates or there is wrinkling of the skin like crushed tissue-paper or a deflated balloon (*see Figs* 25 26, 27) Bacilli take on diphtheroid and other partially staining appearances (*see* p 138 and *Fig* 75)

The reaction may last only a few days, or may be prolonged for weeks or even months It may come on periodically at regular or irregular intervals, fresh lesions or groups of lesions being affected on successive occasions It may be confined to the face or may affect all parts of the body (*see Figs* 18 20 21 39)

In severe cases nodules and other thickened lesions may shed their epithelial covering leaving ulcerated surfaces which do not heal until the reaction has subsided This condition is associated with the "stage of absorption and expulsion" described below

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(p 204) In such cases there is often a marked degree of secondary anæmia in which the hæmoglobin index may fall to less than 40 per cent. This may be due to destruction of erythrocytes by the hypertrophied retriculo-endothelial system as occurs in malaria, kala-azar and other diseases.

Lepra reaction in the lepromatous type of leprosy is generally associated with bad physical health. It may be initiated by a complicating or intercurrent disease or by anything which lowers the patient's resistance Climatic conditions, such as extremes of heat or cold predispose to this state. Among the commonest causes are excessive treatment with chaulmoogra or other drugs, or intravenous injections of arsenicals for syphilis. Similarly infected nerves may also be involved in lepra reaction This causes *their sudden swelling accompanied* by severe pain both in the main nerves and in their branches and distribution, and also marked increase of motor sensory and trophic disturbances

The decline of lepra reaction may be nearly as abrupt as its onset, *or it may take place more slowly* The *acute condition* is accompanied by diapedesis of leucocytes, especially polymorphs, and the destruction of bacilli but the patient is left so weak that bacilli *multiply once more and the final condition of the patient* is worse than before.

It is sometimes difficult to distinguish between lepra reaction and acute intercurrent febrile conditions complicating leprosy The main distinguishing feature in the latter is that the lesions tend to flatten out instead of becoming more prominent. On the other hand an intercurrent disease like malaria may itself light up lepra reaction and the two conditions may be found side by side.

In the lepromatous type potassium iodide, even in small doses, has the power of producing a condition similar to lepra reaction, with general febrile symptoms and swelling of lesions. These symptoms pass away rapidly—within a few days—as the iodide is eliminated from the body But in sensitized or debilitated patients the iodide reaction is apt to continue into the acute condition described above.

Acute lepra reaction does not occur with equal frequency in all endemic countries. In India it is common. One of the writers (E M.) in an extensive tour of leprosaria, found it very rare in East and Central Africa, but *commoner in Rhodesia*, South Africa, and the West Indies.

The *subacute form* of lepra reaction is similar in nature but much milder in degree *than the acute*. It comes on more slowly and

insidiously and may not be recognized until under treatment it clears up leaving the patient in a definitely better condition

Reaction in the Neural Type.—In the sudden congestion and swelling of lesions this condition resembles that just described but it differs in that it is associated with the tuberculoid form of lesion (*see Figs* 52 55, 57 65) As such lesions are generally more limited in extent the febrile and toxic symptoms are accordingly less. In tuberculoid lesions bacilli are as a rule few in number The exception is in the *reacting major* tuberculoid where bacilli can be found in considerable numbers, though far fewer than in the reacting leproma.

In both forms the tissue reaction shows an attempt to destroy or burn up the bacilli In the tuberculoid this attempt is successful. The fire, like that in a forge, is intense and the bacilli are destroyed though in the process there may sometimes be destruction of tissue and even ulceration followed after healing by considerable scar formation (*see Figs* 53 56)

In the lepromatous form there is, as mentioned above, destruction of bacilli but there are more bacilli present to be destroyed and the reactionary fire is less fierce The weakness of the patient and the toxæmia resulting from the reaction are so great that there is later further increase of bacilli and the net result is apt to leave the patient worse than before.

In the ring-shaped form of tuberculoid lepride the reaction may be confined to the margin, leaving when it subsides a distinct hypopigmented ring In other leprides the residual macule left may resemble the simple lepride (*see* pp 180 251 and *Fig* 56)

With or without reaction in tuberculoid leprides there may occur an acute condition in affected nerve-trunks and branches. This is similar to but often more severe than, what we have described above as occurring in the lepromatous type The nerves become swollen, congested and tender Patients are unable to move the part without the greatest pain, nor can they bear the slightest pressure along the course of the nerves Such reactions may sometimes continue for a month or more and be accompanied by febrile symptoms. If the reaction is less severe, the patient complains of neuralgic pains. Also the signs of nerve irritation show themselves in the parts supplied by the nerve-trunk. These vary with the severity of the reaction, the size of the affected nerve, and the extent of its involvement

Blisters of varying depth and circumference may be formed or the deeper tissues may be involved with sloughing of the connective tissue and even destruction of bone. There is a

sudden acute involvement of the tissues which would otherwise be subject to the slow chronic atrophic process which we have described above Sometimes blisters or groups of blisters will appear without any noticeable reactionary signs in the nerve-trunks.

The nerve-trunks of the limbs are the most commonly affected, and perforating ulcers are frequently the result of a nerve reaction in the lower limb In one case a severe reaction of the great sciatic nerve and its branches was accompanied by considerable necrosis of the superficial and deep structures of the heel. But the nerves of the trunk may be affected in a similar manner In one case a nerve reaction was accompanied by a condition resembling herpes zoster with papules in the areas of distribution of two intercostal nerves, and intense pain (*see Fig* 30)

The Cause of Lepra Reaction is somewhat obscure. Under the *lepromin test* (p 156) we have mentioned that the injection of lepromin causes distant focal reactions. It is not unlikely therefore, that this condition is caused by the products of bacillary disintegration. What is not clear is the process which causes bacilli suddenly to break up or sets free in the tissues their disintegration products, thereby causing the reaction. The sudden onset of signs apart from any corresponding increase in the number of bacilli suggests that it is at least partly an allergic condition. The specific action of the iodides in causing focal reactions (*see* p 263) seems to depend on their setting free bacillary products in the tissues, though how they bring about this effect is not known. It must be an indirect action, since direct injection of iodide solution into leprous lesions does not bring about locally a similar reaction.

The Plantar Hyperalgesia Test.—Ryrie (1939) has pointed out that there is a definite relationship between the activity of leprosy and plantar hyperalgesia. This sign is elicited by stroking firmly and evenly along the plantar surface from heel to toes In neural cases the test is obscured by anæsthesia of the sole, and it is of most use in L1 and L2 cases. Positive results are shown by the degree of pain caused on stroking Its value is in finding out in time cases which though not showing signs of reaction, are in the danger zone, so that steps may be taken to prevent reaction.

CHAPTER XIII

LEPROUS LESIONS CONSIDERED REGIONALLY

Parts First and Most Conspicuously Affected.—The parts of the body most exposed to the atmosphere, and therefore to extremes of heat and cold such as the hands and face in those wearing European dress, are more liable to be affected by leprosy at an early stage In those who walk about without shoes, especially in a rocky country the feet are liable to early lesions. Injury to any part of the body may determine the formation of a lesion at that point, probably due to a local weakening of resistance

The auricles are perhaps more constantly affected than any other part of the body (*see Fig* 23) This may be caused by the pressure on them at night in those accustomed to lie with the side of the head pressing on the pillow causing arrest of the blood-flow through the capillaries and giving a chance for the bacilli to gain a footing and begin a lesion. It may also be due to vascular stasis resulting from the peculiarities of anatomical structure and from the changes of temperature to which the ears are liable in their prominent and exposed position. In a suspected case of leprosy always look first at the auricles, and especially at the lobules, to clear up the diagnosis. It is easy to detect any thickening of the lobule between the finger and the thumb In a case of leprosy where the ear is affected it is generally easy to make a diagnosis by examining for acid fast bacilli a smear taken from the lobule. (*See also* Chapter X.)

Parts Seldom or Never Affected.—Hansen and Looft state that they have never seen nodular leprosy on the palms of the hands or the soles of the feet, and that nodular lesions are quite exceptional on the scrotum and penis We found leprous tissue containing abundant lepra bacilli in the palms of 53 and in the soles of 52 of 77 cases of lepromatous leprosy examined at the Gobra Leper Hospital Calcutta and of the same 77 patients, abundant lepra bacilli were present in the scrotums of 33 The probable reason why Hansen and Looft failed to find leprous tissue in the hands and soles of the feet was that the thick epithelium prevents the lepromata from standing out in the form of nodules

as they do in parts where the epithelium is thinner In other words, the skin lesions of these parts tend as a rule, to be of the diffuse rather than of the nodular type. (*See Figs* 14, 37)

HEAD AND NECK

There was formerly an idea that the scalp is seldom affected in leprosy This is owing to its anatomical structure and the fact that lesions tend to be hidden by the hair Leprous lesions of both neural and lepromatous types are, however much more common than was supposed Leprous alopecia is not infrequent in China, Japan and Africa, though it appears to be less common in India (*see Fig* 33)

While the neck is remarkably free from initial and early lesions protected as it is by its concave shape, it soon becomes affected as the disease advances. The cutaneous branches of the cervical plexus are sometimes very conspicuous, especially the great auricular (*see Fig* 65)

Initial lesions of the face are common. This probably is due largely to three causes (1) The face is exposed to extremes of heat and cold and to injuries and irritation leading to scratching (2) The nasal mucosa is frequently abraded during nasal catarrh, or through picking of the nose, as the result of the reflex irritation caused by intestinal parasites While the lesion of the nasal mucosa may itself pass unnoticed, the lesions of the skin of the nose, cheeks eyebrows and forehead, due to lymphatic spread from the mucosa, are more conspicuous (*see Figs* 54, 57) (3) There is the fact previously mentioned that primary infection frequently takes place through contact with infected bedclothes through some slight abrasion of the epithelium when the cheek is laid on an infected pillow

All types and subtypes of lesions are common on the face. Sometimes the first sign is the appearance of small, round erythematous patches which may either be anæsthetic to light touch or show a few bacilli on bacteriological examination. At other times there may appear a diffuse erythema of a large area on either one or both sides of the face. In the lepromatous type, as the disease progresses, there is diffuse infiltration which may not at first be noticeable. Later as the deeper layers are attacked the skin becomes deeply creased and corrugated, or there may be nodulation either by itself or superadded to the diffuse lesion (*see Figs* 15 16, 87) In such cases the appearance commonly known as leontiasis is produced the eyebrows becoming beetled and the nose characteristically thickened.

In the nerve type it is not uncommon to find partial anæsthesia of the face, generally accompanied by paralysis or paresis of the small muscles of the face. This leads to a peculiar mask like expression very characteristic of this type of leprosy Paralysis or paresis of the orbicularis palpebrarum leads to inability to close the eyelids completely while paresis of the sphincter of the mouth may lead to dribbling of the saliva (*See Fig* 35 51)

According to Hansen and Looft the senses of smell and taste may be very much diminished or entirely lost. This is due chiefly to the condition of the mucosa of the nose and mouth The 3rd, 4th and 6th cranial nerves are seldom or never directly affected.

When an affected supra-orbital nerve passes into the orbit through a bony foramen pressure on the swollen nerve may cause complete anæsthesia of the area supplied followed by paresis of the underlying muscle (*see Fig* 61)

Pressure on the facial nerve as it passes through the stylomastoid foramen, due to swelling of the nerve within the unyielding bone, frequently causes complete facial paralysis on that side, which is generally permanent.

There is no evidence that the 8th 9th 10th, 11th and 12th cranial nerves are affected to any appreciable extent as a result of leprosy

The hair of the face is absent in advanced cases of both neural and lepromatous leprosy but more especially in the latter The hair of the eyebrows disappears first as a rule from the outer part, depilation passing gradually inwards as the disease progresses. There may or may not be complete destruction of the hair follicles. The finer hairs are, as a rule much less affected than the larger coarser ones.

Lesions of the Eye.—These may be divided into those which are caused directly by the presence of lepra bacilli in the eye and those which are due to interference with the nerve-supply of the eyeball and its appendages

1 *Lesions due to the Presence of Bacilli in the Eye* —As in other regions, bacilli may either reach the eye by spread through the lymphatics from adjacent affected areas, or may be carried from some other focus through the blood-stream. There remains the remote possibility of direct inoculation through some abrasion of the conjunctiva or cornea, but we are not aware that any instance of this has been recorded

When the adjacent skin of the face is affected it is not uncommon for the disease to spread to the conjunctiva, which becomes injected and thickened as far as the corneal margin When the lesion is

diffuse it closely resembles ordinary conjunctivitis at first, though, as time goes on, thickening becomes more marked. Nodules may be formed which sometimes resemble pterygium. Later the disease may begin to spread and attack the cornea (*see Fig* 34) When the disease is of the more superficial subtype, a ground-glass-like appearance, resembling pannus, is noticed gradually spreading inwards from the corneal margin, most frequently in the upper sector or there may be numerous small opacities If this condition which is caused by superficial or interstitial infiltration of the cornea spreads over the pupil it may result in considerable loss of vision but even without spreading so far it often interferes with vision by affecting the curve of the cornea. Where the lesion spreading to the cornea is deeper than the conjunctiva, and the sclera has been affected a deeper lesion of the cornea may be expected This may be in the form of a diffuse vascular infiltration or nodules of the cornea occur The disease may spread still deeper and nodules bulge into the anterior chamber from the posterior surface of the cornea.

The disease frequently spreads from the sclera along the antero ciliary vessels to the ciliary body and the iris, setting up irido cyclitis, which closely resembles the corresponding lesion foun in syphilis Nodules of the iris may develop in which case it seldom possible to prevent destruction of the eye. The reti and optic nerve may occasionally be attacked by extension fro the choroid.

While the eye is most commonly invaded by extension of disease through the lymphatics from the adjacent infected skin from the nasal mucosa, it may also be affected through the blo stream but evidence of this is rare, and it is not often that the is affected where there has not previously been some sign of o adjacent lesions It is uncommon for the vitreous the retina the optic nerve to be primarily affected when other parts of eye are exempt

A mild infection of the eye may be suddenly changed in severe general ophthalmia by the onset of the reactio phase

Borthen is quoted as stating that only 8·08 per cent of wome 1·67 per cent of men, suffering from tubercular leprosy without some form of disease of the eyes or adnexa. In Ind is certainly not true at least if we take tubercular leprosy to the lepromatous type In our experience not more than 5 per cent of lepromatous cases have any disease of the eyes and caused by leprosy and the same is true throughout mos

of Africa. The difference in these findings is due partly to the indefiniteness of the term tubercular leprosy and partly to the larger proportion of severe cases among Europeans possibly also to the greater concentration of leprosy on the face in climates where the body is well covered with clothes.

2 *Lesions of the Eye in Neural Leprosy*—In the neural type of leprosy the eye is often included in the area of a widespread tuberculoid or simple lepride. When this lesion heals it leaves a certain amount of new fibrous tissue which later contracts It also leaves behind a greater or less degree of anæsthesia which is apt to be followed by paresis of the underlying muscles or infection may spread up and cause swelling of the facial nerve, which is nipped in its passage through the stylomastoid foramen with complete unilateral paralysis of the facial muscles

The anæsthesia of the cornea, the contraction of fibrous tissue, and the paresis or paralysis of the muscles of the eyelids interfere with the corneal reflex and the protective mechanism of the eyeball The eyelids remain open at night and cannot be completely closed during the day and irritation is caused by the entry of dust and insects (*see Figs* 35, 51) Unless measures are taken to protect the eyeball ulceration of the cornea and general ophthalmia are apt to follow

Ectropion often leads to eversion of the punctum lacrimale and the flowing of lacrimal fluid down the cheeks. When the region of the lacrimal sac is the site of deep leprous infiltration, or when there is disease of the nose, the lacrimal passages may be blocked and an abscess of the lacrimal sac result.

Lesions of the Nose—While in warm countries, where few clothes are worn and many parts of the body are exposed to the entry of lepra bacilli through the epithelium primary lesions are widely scattered over the body it has been suggested that in colder countries a very large number of lepers are first infected through the nasal mucosa (p 88) The epithelium of the nasal mucosa is very thin and, especially when in a catarrhal condition is very liable to abrasions througn which bacilli may enter The habit of picking the nose, so common in children especially when there is reflex irritation from intestinal parasites, also explains a likely path of entrance of lepra bacilli. As a matter of fact it is the parts of the mucosa within reach of the fingers that are most commonly affected viz. that covering the anterior or cartilaginous part of the septum and that covering the inferior turbinated bone The vessels of the lower part of the septum are usually dilated and it is from this site that epistaxis takes place It is this part of

the septum that is so commonly perforated in advanced lepromatous cases.

All the degrees and types of lesions mentioned as occurring in the skin are likewise found in the nasal mucous membrane, from the lepride in which bacilli cannot be found on bacteriological examination to grosser lesions with nodulation and ulceration In the former there is dryness of the mucosa. Patients sometimes give the history of having ceased to suffer from nasal catarrh one or two years previous to the appearance of the first visible signs of leprosy The nasal mucosa in such cases is lighter in colour and dry the normal bright red, moist appearance being absent.

In other cases there is a more massive infection of the nasal cavity The inferior turbinate has a nodular appearance and ulceration or old scars may be seen on the septum. Perforation and destruction of the septum may occur owing to the cutting off of the blood-supply of the septal cartilage. It is a comparatively uncommon occurrence to get destruction of the bony septum, though the vomer bone may occasionally be affected Flattening of the nose is common in such cases. (*See Fig* 32)

Some have maintained that this destruction of the septum is a sign of accompanying syphilis. We found perforation of the septum and flattening of the nose in four advanced lepers in Gobra hospital who had a negative Wassermann reaction although they had never been treated for syphilis.

When ulceration is present in the nasal cavity the discharge may contain very large numbers of bacilli while the patient is still unaware that he is suffering from the disease. He may in this way be a great source of danger to others. (*See* p 152)

When ulceration is taking place there may be severe attacks of epistaxis, which may be the first manifestations of the disease.

Mouth, Pharynx, and Upper Air Passages —Lesions of the lips are not uncommon as an extension from the skin of the face, though they are rare as primary lesions Nodules frequently appear at the outer margin of the lips, and fibrous contraction may cause partial stenosis. Nodulation of the tongue is common in advanced cases of the lepromatous type.

The palate may be the site of either diffuse or nodular lesions. The soft palate and the fauces may become ulcerated owing to the breaking down of leprous tissue, and, when the ulcers heal, partial obstruction of the fauces may result. Perforation of the palate sometimes occurs in leprosy but it may generally be looked upon as a result of accompanying syphilis.

The larynx is not affected primarily but by extension from the

mucous membrane of the mouth and pharynx. Involvement occurs much more commonly than is usually recognized, because the onset is insidious and there may be considerable infiltration of the larynx without inconvenience to the patient on account of the local analgesic effect of leprous invasion there are seldom the irritation and pain so common in a minor degree of involvement in tuberculosis.

In severe lepromatous cases the soft palate, uvula and ary epiglottic folds become swollen, hard, and smooth Later tubercles may appear with whitish-yellow nodules from the size of a pin's head to that of a split pea. In the worst cases this may go on to ulceration, the ulcers somewhat resembling those found in syphilis, but not as a rule involving the bone. After the healing of ulcers of the soft palate and pharynx, contraction and deformity take place, and the patient may have considerable difficulty in swallowing Contraction of the glottis may result in dyspnœa necessitating tracheotomy failure to diagnose this condition sometimes results in the death of the patient. More commonly fibrous contraction without ulceration takes place and there is a tendency towards healing without inconvenience to the patient. In many of these cases the voice is reduced to a harsh throaty whisper Destruction and exfoliation of cartilage have been described but seldom occur and when found suggest accompanying syphilis

In primary neural leprosy the throat is seldom affected but the scars of former leprous lesions may persist in cases which, formerly lepromatous, have resolved into the secondary neural type.

The trachea and bronchi are involved in some cases to a considerable extent. Enormous masses of bacilli have been found in the bronchial mucosa and in swollen peritracheal lymph nodes. In such cases lepra reaction may be followed by ulceration of nodules, and large quantities of purulent material rich in *Mycobacterium lepræ* may be coughed up suggesting pulmonary involvement.

When there is much fibrous and scar tissue resulting from healed ulcers in the nose and mouth, the senses of taste and smell may be partially or wholly lost In cases in which the nerve type is most marked in the face, the lingual nerve may be affected and the power of taste impaired though in our experience this is only to a limited extent. The tongue and palate may appear deeply pigmented.

Lesions of the pharynx and larynx are always exaggerated during the reactionary phase Sometimes their severity is increased by the presence of syphilis

LESIONS OF THE UPPER EXTREMITIES

As we have shown initial lesions are common on the upper extremities (p 159) In those who wear European dress, these tend to be limited to the hands while in those who wear no clothing on the upper extremities the outer part of the upper arm and shoulder on which they lie at night (on the right side more than on the left) shows the largest number of apparently primary lesions The flexor surfaces are much less affected than the extensor both as regards primary and subsequent lesions

The extensor surfaces as liable to injury are more affected than the flexor Thus the elbow the ulnar surface of the right hand, *and the ulnar nerve as it passes round the elbow are much affected* In plotting out sensory and trophic changes in well-advanced cases of the neural type it may be difficult to distinguish between active and residual leprides and lesions of the secondary polyneuritic subtype.

1 **Skin.**—Various characteristics of leprides and polyneuritic lesions have already been described on pp 179, 180 189, but a more detailed description of the nails in the lepromatous type is necessary The most marked changes in the nails are seen when there is deep diffuse infiltration of the skin of the fingers There is thinning of the nail and the longitudinal ridging of the nail bed shows up *This may be due to interference with the* posterior part of the nail-fold, which has to do with the formation of the more superficial part of the nail, the deeper part of the nail being formed by the matrix. When the process has gone still further the nail becomes wavy and fragmented The lamellæ of the nail plate are not welded together in a homogeneous whole, as the process of keratinization is defective Still later only a few scaly remnants may remain At this stage, even should the process of leprous infiltration of the skin cease, and complete resolution of infiltrates take place the nails can never be restored to normal as their matrices have been destroyed. This process of destruction *is very similar to that which takes place in the hair* follicles in the deeper lesions of the skin. If, however resolution takes place before complete destruction of the nail fold has occurred, there is restoration of the nail, though it may remain somewhat deformed (*see Fig* 27)

In acroteric lesions of the neural type quite a different appearance presents itself The nail is thickened but has a tendency to split transversely at the end

Blebs and blisters are common on the hands and fingers. These are often trophic and may follow an inflammatory reaction

in the nerve-trunk supplying the part. Still more frequently they are the result of injuries, such as burns and bruises, of which the patient may be quite unaware because of the absence of sensation.

As previously mentioned (p 191) lepromatous lesions of the palms of the hands are quite frequent. (*See Figs* 22 27)

2. Muscles.—Among the polyneuritic lesions of the neural type muscular atrophies are the most conspicuous, resulting from disease of the ulnar posterior interosseous and median nerves The small intrinsic muscles of the hand are affected There is flattening of the thenar and hypothenar eminences, and prominence of the metacarpal bones, both anteriorly and posteriorly due to atrophy of the interossei and lumbricales. There is loss of abductor and adductor power of the fingers The muscular fibres are replaced by fibrous tissue, which may in turn contract and cause deformities of the fingers The characteristic *main en griffe* develops, with hyperextension of the metacarpophalangeal and flexion of the interphalangeal joints (*see Figs* 51 62 63) The fingers may become fixed in a flexed position, partly because of fibrous contraction and partly from disuse

The muscles of the forearm, especially flexors are not infrequently partially paralysed, and wrist-drop may result, but this is chiefly the result of disuse Apart from the general debility of leprosy there is seldom any similar affection of the upper arm.

3. Bones.—Muscular changes in the hand are as a rule accompanied by and are perhaps to a large extent the cause of, decalcification and softening of the bones, especially those of the fingers. The fact that these changes can be lessened by suitable active and passive exercises strengthens this view of the causation. The phalanges become thin and short and may disappear with or without sepsis and the occurrence of an open wound. The metacarpals are less often affected. As the bones become shortened the skin contracts and a claw like nail may be found planted at the end of a metacarpal.

This process may be complicated by the entrance of septic organisms, abscess formation, and necrosis of bone. The metacarpus and carpus may be lost seldom by slow absorption, generally by septic necrosis

In cases of skin leprosy there may be enlargement of the lymphatic glands on the inner side of the upper arm, and also of the axillary glands. This may be due either to the presence of lepra bacilli or to absorption from some complicating septic wound In all stages of nerve leprosy the nerves of the upper limbs are subject

to severe attacks of pain, which generally correspond to the reactionary phase.

LESIONS OF THE LOWER EXTREMITIES

Initial lesions are not uncommon on the lower limbs and in India, among dwellers in hilly tracts who wear no shoes and whose feet are very liable to be injured, it is most commonly in the feet that the first signs of leprosy are noticed (p 159) While some of these lesions may represent the actual site of infection many others are due to the patient being unable to avoid injury to the feet owing to loss of sensation. It is remarkable how long patients may suffer from the more chronic types of leprosy without noticing that anything is wrong One patient never realized his condition until he discovered one day on taking off his boots, that his hallux was doubled under his foot inside the boot. In others the first sign noticed is a trophic bleb or blister In such cases the disease may have existed for many years without the knowledge of the patient (see pp. 187 188)

As in the arms the extensor surfaces are much more commonly the site of lesions than the flexor The superficial peroneal nerve, corresponding to the ulnar in the upper limb is the nerve most liable to injury because of its superficial position as it passes round the neck of the fibula. Drop-foot resulting from peroneal paralysis is not uncommon. The posterior tibial nerve is also often involved

Skin, muscle, and bone lesions corresponding to those mentioned in the upper limb (pp 198 199) are frequent when extensive nerve involvement exists

An ichthyotic condition of the legs is common especially in lepromatous cases. The skin of the front of the leg appears stretched, shiny and hairless it does not sweat, and may become dry and cracked. The appearance is an exaggeration of that found in certain deficiency diseases

In others there is an elephantoid swelling of the feet, sometimes extending up the legs to the knees (see Fig 31) There are hyperplasia of the skin, achromatic anæsthetic patches, and mutilation of the toes In some cases there is extreme hyperkeratosis with a rough file like outer surface. Whether this condition is due to leprosy alone or is provoked by other complicating infections, it is difficult to say

Perforating Ulcers of the sole of the foot are perhaps the most painful and crippling lesions found in leprosy They occur chiefly in neural and mixed cases and are due primarily to

involvement of the nerves supplying the sole of the foot There are several factors which contribute to their origin and prevent their healing

1 *Hyperkeratosis and parakeratosis* The epithelium of the sole of the foot becomes thickened and lacking in elasticity This leads to cracking of the skin and formation of ulcers, especially at the points of greatest flexion and pressure. A crease is thus formed which because of the thickness of the surrounding epithelium has very little chance of healing every movement of the foot tending to aggravate it

2 *The wasting of the small muscles of the sole* removes the support ordinarily afforded to the foot which instead of having a soft elastic surface to rest on, loses its natural padding while the arch of the foot becomes flattened for want of its muscular support.

3 Owing to *anesthesia of the skin of the sole* injury may be inflicted on the foot without the patient being aware of it

4. Following on *trophic changes in the muscles and periosteum*, decalcification and absorption of the bone proceed in a manner similar to that in the hands. In the foot, such absorption may be carried to an even greater extent than in the hands owing to the pressure of the body weight there is gradual attrition of the bones through which the pressure of the body is transmitted (*see Figs* 62 64, 66) In one case we found complete disappearance of the astragalus while the distal ends of the tibia and fibula were worn down into a sharp point which rested in a hole in the dorsum of the calcaneum This had taken place without any necrosis or other septic process

5 *By a combination of the above factors* we often get the entrance of septic organisms through cracks in the skin followed by necrosis or caries of the already weakened bones. In this way true perforating ulcers are formed which will not heal up until the diseased bone is evacuated. Perforating ulcers may result from severe reactions in nerves (*see* p 189)

As in the upper limbs, so also in the lower limbs, nodulation is often most marked at the *sites of injury and friction*. In India large, exceedingly hard nodules are common on the internal and external malleoli, especially the latter because of the intermittent pressure and friction caused by the manner of squatting with crossed legs In those who wear hard ill fitting shoes, nodules often appear on the dorsal surface of the toes Neuralgic pains are common in the great sciatic nerve and the patient may feel tingling when he sits on a chair owing to pressure on this nerve

The femoral lymphatic nodes may be markedly swollen, especially during exacerbations When there is any septic process

in the legs or feet, suppuration of the femoral glands may take place The abscess may break down and an ulcerating surface be produced which discharges large numbers of lepra bacilli. Such ulcers will not, as a rule, heal up till all the bacilli have been discharged, and the hard, fibrous tissue of the mass of glands has been absorbed. Lymphangitis is a not uncommon symptom in leprosy especially in the lower limbs. In one case a patient was treated for this complaint for several years without a diagnosis of leprosy being made

LESIONS OF THE TRUNK AND INTERNAL ORGANS

Lesions of the Skin of the Trunk.—These do not differ in any essential respect from the lesions of the extremities The middle line both in the front and back is less affected than other parts Initial lesions are comparatively seldom found on the front of the chest probably because it is protected both by clothes and by the upper limbs In nerve leprosy we have found typical herpes zoster with lepra bacilli in the papules in a case where formerly repeated search had failed to find lepra bacilli.

Hansen and Looft mention that nodules are exceptional on the flexor surfaces of the extremities and on the breast and the abdomen. We agree with regard to the flexor surfaces, which are certainly much less affected than the extensor surfaces The breast and abdomen, however are extensively affected in India. Induration and prominence of the nipple are very common, and may be followed by retraction of the nipple during the phase of resolution. In India, where a thick roll of cloth is commonly worn round the waist, it is remarkable that obvious lesions of the abdomen are almost entirely confined to the upper half the region covered by and constricted by the cloth may however have inconspicuous diffuse infiltration. Doubtless this explains the difference between the observations of Hansen and our own, as in Norway where Hansen's observations were made the breast and abdomen are covered with warm clothes whereas in India they are left more or less uncovered

Lesions of the Internal Organs.—Most authorities are of the opinion that leprosy of the lungs does not occur The patient may cough up large quantities of purulent sputum, containing numbers of acid fast bacilli, but it is considered that this is due to the bursting and discharge of nodules in the trachea and upper bronchi and not to an affection of the lungs. It is important to distinguish this condition from pulmonary tuberculosis and it

must be remembered that the latter disease not infrequently complicates the severer forms of leprosy When this is suspected the sputum should be tested by culture or by animal inoculation which is positive in tuberculosis and negative in leprosy One of the best methods of distinguishing between the two conditions is the comparative ease with which that caused by leprosy yields to treatment

It is not uncommon to find lepromatous changes in the spleen and liver Hilary Ross found a raised tyrosin index for euglobulin in the sera of 147 out of 150 cases, the greatest variation being in active advanced cases also the albumin-globulin ratio was below normal in 123 of the 147 She suggests that hepatic dysfunction and liver damage may be an aetiological factor in the disturbed protein metabolism (*See also* Chapter IX) ✓

Lesions of the Genital Organs.—The testicles are affected in a majority of advanced skin and mixed cases, but the patients seldom complain of pain or discomfort (p 141) It is much less common for the ovaries to be affected and sterility is more prevalent in the male than in the female. (*See* p 60) Gynecomastia is a not uncommon condition in cases in which the testicles have been destroyed by fibrous contraction (*see Fig* 32)

Mitsuda describes lesions along the capillary veins in the muscular layer of the uterine wall in cases of nodular leprosy and lepra cells occasionally in the endometrium. Possibly the embryo may become infected in such cases. The ovary is seldom affected hence sterility is uncommon among leprous women (p 130)

McCoy summarizes his comparison of the fecundity of lepers in the Molokai leper settlement with that of the general population as follows (1) The birth rate of the Molokai settlement is probably about two-thirds as high as that of the non-leprous members of the same race outside but the data for an entirely just comparison are lacking (2) The birth rate among lepers appears to depend on the fertility of the male which probably is materially reduced (3) The fertility of the female does not appear to be impaired. (*See also* p 60)

It is not unlikely that the more frequent impairment of the testicles as compared with the ovaries is due to their dependent position and their liability to injury as we have noticed that other parts exposed to injury are those in which the worst leprous lesions are most frequently found (*see Fig* 37)

The question of congenital spread of the disease has been discussed in this connexion but there is no reason to believe that this occurs (p 132)

Late Lesions of the Internal Viscera.—In advanced cases of leprosy there are frequently functional disorders showing that the internal organs are considerably affected. This, however, does not imply that they are directly affected by lepra bacilli. Waxy degeneration of the bowels, liver and kidneys is not uncommon in such cases. There may be diarrhœa or dysentery, upsetting of the thermic centres, and general debility due to impaired hepatic function.

Lymph-nodes.—Where there is a gross infection of a part—that is where there are abundant lepra bacilli to be found—it is common for the lymph nodes draining the part to be enlarged. The commonest sites of enlarged nodes are the neck, especially in the anterior triangle, the inner side of the arm just above the elbow, the axillæ, and the groin. Suppuration may take place either with or without pyogenic infection. Where there is no mixed infection the pus is sterile and contains large masses of lepra bacilli in typical bundles. Where there is a mixed infection, as is most common in the groin, the wound will not heal until all the leprous tissue has been discharged. Lymphangitis is not uncommon, and it should be borne in mind in endemic areas that this may be a prodromal sign of leprosy. (*See also* Chapter IX.)

THE STAGES OF LEPROSY

In most cases of leprosy there is sooner or later a tendency towards spontaneous cure, but the process is different in each of the two types.

The course of a typical progressive lepromatous case may conveniently be divided into four stages:—

1. *Diffusion*, when the original focal lesions spread and form widespread diffuse lesions.

2. *Thickening and nodulation*, when the diffuse lesions spread to the deeper layers of the skin and nodulation occurs.

3. *Resolution and expulsion*, in which bacilli are either absorbed and destroyed by the body tissues, or are got rid of from the body by being expelled in common with dead and liquefied leproma from abscesses, or gradually discharged from ulcerating surfaces. Expulsion is more prominent in weaker patients and absorption in the stronger, but in most the two processes proceed side by side. Only a proportion of patients survive, the rest pass on into the final stage.

4. *Cachexia* with extensive ulceration, often accompanied by secondary infection, which results in anæmia, renal disease and other complications from which   tient suc   f he

survives he is generally blind and badly deformed and crippled as resolution in lepromatous cases is commonly accompanied by the appearance or increase of polyneuritic signs.

In a smaller proportion of lepromatous cases the leproma and bacilli are absorbed and recovery accompanied by less deformity may result. When the healing process has taken place nodules may leave flat scars like deep burns (*see Figs* 27 88) and diffuse lesions with an appearance like crushed tissue-paper or a deflated child's balloon, the original elastic and collaginous fibres of the skin having been destroyed (*see Figs* 25, 26) Histologically degenerating lepra cells show an accumulation of lipoid material which stains yellow with Sudan III The degree of new fibrous-tissue formation varies directly according to the depth of skin affected, the degree of cellular reaction, and the duration of the lesion.

In cases of the *neural type* resolution is brought about in a different way As is mentioned above the spreading lepride leaves in its centre an area of resolution. If such lesions are not arrested by treatment or spontaneously at an earlier stage, they continue to spread and coalesce until large areas are covered or even the whole skin is affected In this way at long last all active disease may die out, like a bush fire that burns itself out.

As mentioned above, resolution of major tuberculoids may be very rapid and accompanied by a considerable amount of permanent scar formation (*see Figs* 53 56) Minor tuberculoids often heal up at the centre with little or no clinical change in the texture of the skin (*see Figs* 32 41) though slight sensory and pigmentary changes may persist.

Secondary polyneuritic lesions tend to develop sooner or later both in lepromatous cases and in primary neural cases. (*See Scheme* p 176)

These lesions are the result of pressure on the axis-cylinders, caused first by cellular infiltration and later by tissue contraction which strangulates the nerve-bundles still further While polyneuritic lesions are associated chiefly with the advanced stages of both types of leprosy they may also be found in the earlier stages sometimes the anæsthetic subtype precedes the more aggravated lepromatous type.

MENTAL CONDITION OF THE PATIENT

Left to himself the condition of the leprous patient is a most deplorable one. The long duration of the disease exclusion from work and from intercourse with his fellows, and the ostracism to

which he is subjected cause mental depression, and sometimes even acute melancholia. Where lepers live in agricultural settlements, employment suited to their capacity for work and association with others who are in the same condition has a cheering effect upon them. As in tuberculosis, leprous patients are liable to alternating periods of hopefulness and despair. This is largely due to the alternating phases through which the disease keeps passing. Many of the symptoms may have subsided and the patient may consider that he is improving rapidly when suddenly the reactionary phase appears, all the symptoms are aggravated and he is plunged once more into despair.

Such mental depression has a very bad effect upon the general condition of the patient, as cheerfulness is one of the main essentials for recovery. There is no organic mental disease known to be associated with leprosy. (*See* Chapter XVIII.)

BIOCHEMISTRY OF THE BLOOD

For lack of space this important subject has not been dealt with. Readers are referred to the paper on this subject by Villela (1938) which gives an exhaustive list of references.

CHAPTER XII

INCIDENCE

Sex Incidence.—There is a general consensus of opinion that leprosy is more common and takes a severer form among men than among women, occurring usually in the proportion of about 2 to 1. In the few places where the number of female lepers exceeds that of the males there is often some special local reason such as the longer survival of the former or women being more exposed to infection than men. In Norway the few remaining cases show an excess of females, apparently due to their greater longevity and the milder disease on the average among females, who appear to have somewhat greater resistance to severe infections. The effect of local conditions is seen in the Loyalty Islands, where Laquieze attributes the comparatively high rate among females to great sexual promiscuity. In Basutoland female lepers are in excess, possibly because the women are sedentary and tend towards obesity.

The causes of the usually greater frequency and severity of leprosy in males may be either environmental or physiological. On the whole, males lead a life which is less guarded, they mix more freely with strangers, and are therefore more likely to be exposed to infection. In the Indian household the male child is carried in the parents' arms to a greater extent than the female, so that in the event of a leper parent he would be in greater danger of intensive infection.

On the other hand there may be a cause in the cytological or endocrine make up of the female as compared with that of the male which produces higher resistance to the disease.

There is very general agreement that before the age of puberty children of both sexes are about equally affected, and that puberty and childbirth increase for a time the incidence in females. That the considerable excess in males is due to their greater wandering from home and consequently greater exposure to infection is borne out by figures of Lowe indicating that house infections were traced in 87 per cent of women against only 48 per cent of men. Tuberculous data afford evidence of a similar relationship. The sex differences are therefore largely environmental, aided probably

by somewhat greater resistance to infection by females except at periods of life involving special strain. (*See also* Lowe, 1934)

Age Incidence.—*This has* been dealt with under SUSCEPTIBILITY in Chapter VI As in tuberculosis, there seems to be no doubt that the majority of cases are infected during the first two decades. Probably few patients are infected and develop the disease after the age of 40

The graph curve (*Fig* 8) shows the ages at which 3380 lepers first noticed signs of the disease. The statistics were collected from 33 leper asylums scattered all over India. The curve exactly corresponds to a similar curve of 500 leper patients attending the out patient dispensary in Calcutta.

McCoy gives the records of the Molokai settlement from 1909 *showing the age of 1058 patients on admission from which the* percentages are worked out in *Table XVIII* (*See also* Chapter VI)

Table XVIII.—AGE INCIDENCE AT THE MOLOKAI SETTLEMENT

AGE	NO. OF CASES	PERCENTAGE	AGE	NO. OF CASES	PERCENTAGE
1–5	8	0·8	26–30	114	10·8
6–10	56	5 3	31–35	79	7·5
11–15	163	15 4	36–40	89	8·4
16–20	204	9·2	41–45	44	4·2
21–25	143	15·5	46–50	48	4·5

Thus 40 per cent are admitted at ages up to 20 54 per cent at ages up to 25 and 65 per cent at ages up to 30 Taking four years as the average duration of the disease before admission, we should have over 50 per cent infected by the age of 20

As a decline in the whole population of a country is presaged by a decline in the lower age groups so a diminution of leprosy in the child population indicates a tendency of the disease to die out.

Race Incidence.—The question of race susceptibility and resistance to leprosy is a complicated one about which we have still little definite knowledge. Molesworth states that natural selection was probably the dominating influence in determining the present freedom of Europe from leprosy but this opinion is questioned by others.

Hopkins from his experience in the Southern States of America concludes that the Mexican in Texas has less resistance to leprosy than the Texan of American ancestry" and that "the Negro in Louisiana has a higher resistance to leprosy than has the Louisianan of Caucasian ancestry

One of us (E. M.) noted in his visit to the Pretoria Leper Institution in the Transvaal that "the disease appears to be of a severer form among the Europeans than among the natives. Every one of the twelve Europeans admitted during the last twelve months was of the severe lepromatous type, while of the natives admitted during the same period only 25 per cent were lepromatous, the remainder being of the milder neural type more likely to recover The reasons underlying this severity of type among Europeans are worthy of careful investigation All contacts of lepers admitted are examined periodically and it is not likely that the difference between the two classes of patients could be due to milder cases

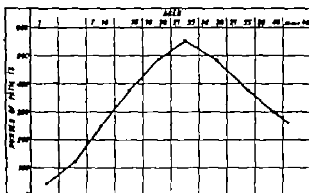


Fig. 8.—Ages at which signs of disease were first noticed by 3980 lepers. Collected from 33 leper asylums scattered over India.

among Europeans escaping detection. Malnutrition is common to both classes of patients, so this could not account for the difference. There are two possible explanations which present themselves (1) That contacts are less close among Europeans and that therefore only the minority of susceptibles in the European community acquire the disease and that in the severe form whereas contacts are so close and so frequent among natives that even non-susceptibles acquire leprosy though only in the milder form and (2) that climatically the European is at a disadvantage in South Africa as regards leprosy or that the disease produces in him more mental and consequently more physical depression and in this way lowers his resistance." (Muir 1940)

The type of leprosy is much more severe in Burma than in India, and among Burmans than among Indians in Burma who are living in the same climatic conditions. The difference is still more marked when we compare leprosy as found in the north-east part

of the Belgian Congo with that in Burma, 10 per cent of case
lepromatous in Congo villages and 52 per cent in Burmese vi
though in the Congo there is apparently a considerably l
total incidence rising to over 40 per mille in some areas.

The percentage of total cases suffering from tuberculoid le
as compared with severe open cases varies considerably on pa
eastward from Barotseland in the west of N Rhodesia to Ny
land as shown in the following table

Table XIX.

	Barotseland	Central and East N. Rhodesia	Nyasaland
Tuberculoid (per cent)	60	22	12
Severe open	11	28	35

It is seen that the proportion of cases with tuberculoid lesions diminishes, and that of severe open cases increases, as one passes from Barotseland to Nyasaland. As severe open cases indicate susceptibility and tuberculoid indicate resistance to the disease, it might at first sight be supposed from the above figures that leprosy is of a milder type in Barotseland than in the central and eastern provinces of Northern Rhodesia and in Nyasaland. However official figures which correspond with the consensus of medical opinion show that leprosy is much more common in Barotseland than elsewhere (13–14 per mille) We have thus the curious phenomenon of a preponderance of the milder type of leprosy in the region where there is the highest number of cases.

We suggest the following explanation of this phenomenon The majority of any population has high natural resistance to leprosy and a small minority are highly susceptible. When the latter are infected they are liable to develop a severe open type, especially if the general health is depressed by malnutrition or complicating diseases Comparatively short and slight contact with an open leper may be sufficient to produce leprosy in such a case A much more prolonged and close contact, however is necessary to produce the disease in the resistant case, and only the milder type with tuberculoid lesions is likely to occur In Nyasaland the type of leprosy is on the whole mild. Lepra reaction, a sign of great susceptibility seldom occurs, trophic ulcers are slight and comparatively uncommon, there are very few child lepers all these indicate racial resistance. The same indications of a mild type are present also in Barotseland

The difference between these two regions is, to use a metaphor not in the bacillary seed nor yet in the basic nature of the body soil but in the intensity with which the seed is cultured The people in Barotseland are dirty and promiscuous in their habits the population is condensed along the Zambesi River the climate is warm and moist and biting insects form a plague create irritation of the skin and favour the scratching in of lepra bacilli precautions are not as a rule taken to isolate infectious cases and prevent the spread of infection. Whereas the people of Nyasaland are better educated cleaner and less promiscuous in their habits, and are accustomed to take more precautions to prevent themselves being infected Presupposing equal racial resistance and the same proportion of susceptibles in each of the two regions, we should expect only slightly fewer severe cases in Nyasaland, as susceptible individuals are liable to acquire the disease whether their contact is major or minor but we should expect a much smaller number of cases of the resistant type in Nyasaland where the chances of intensive infection are so much less. Thus the conditions expected would appear to correspond with the limited facts known

Class Incidence.—As has been shown previously the social condition of the patient has a very marked influence both on the incidence of leprosy and on the severity of the disease. In Norway where the social conditions are very different between the town dwellers and the fisher people in the coast villages, the disease was practically limited to the latter who maintained the old customs of crowding into small rooms and sleeping with two or more persons in one bed (*See* Chapters III and VI)

T ble XV—SOCIAL POSITION OF 50 PATIENTS AT CALCUTTA.

Occup tion	Lepromatous	Neural	Total
Servants	55	110	165
2 Shopkeepers and merchants	32	55	87
3. Clerks	22	45	67
4. Students	19	35	54
5. Professional	30	22	52
6. Engineers, mechanics, etc	6	35	51
7 Housewives	9	16	25
Totals	183	3 6	50

This may be contrasted with India where the distinctions between classes are not to nearly so great an extent dependent upon social status as upon caste. Thus, among the high and the

low the rich and the poor we find Indians sitting and lying upon bedclothes which have been used and soiled by others. If our hypothesis is true that in a very large proportion of cases leprosy is a bed infection, then we have in Indian social customs at least a partial explanation of the reason why the disease is found among all sections of the people in that country

Leprosy is not uncommon among the most wealthy and those of the highest social standing in India. In *Table XX* is shown the social position of 501 cases treated in the outdoor dispensary of the School of Tropical Medicine, Calcutta.

CHAPTER XV

DIAGNOSIS

In the preceding pages we have dealt at length with the clinical signs and symptoms which make up the complex picture of leprosy We now arrange these signs and symptoms in such a way that they may be of use, not only in the diagnosis of leprosy from other diseases but in forming an opinion regarding the causes which have brought about its development for we hold, as we have argued above, that the mere conveyance of lepra bacilli into the body is not sufficient to bring about the disease the soil must in some way or other be prepared, so as to enable the disease germs to grow For this reason a diagnosis of leprosy which does not take cognizance of the predisposing cause is not likely to result in much benefit to the patient.

Importance of Early Diagnosis.—It is easy to diagnose an advanced case of leprosy In Eastern countries lepers themselves know this fact, and often beg at the street corners, exhibiting their sores and deformities in assurance that the passer by will diagnose their complaint and take pity on their plight. But it is not the advanced but the early case of leprosy which needs skill in diagnosis, for speaking generally the earlier the diagnosis the more possibility of cure As we shall show later under TREATMENT the hope of getting rid of the disease depends in many cases upon early diagnosis and treatment.

There are several difficulties which stand in the way of early diagnosis —

1 *Ignorance of the Patient.*—The onset of leprosy being as a rule painless, and the disease resembling as it does trivial complaints such as ringworm, the patient often neglects to seek early medical advice.

2 *Ignorance of Medical Practitioners*—We have come across many instances where medical practitioners living in endemic areas, and holding high rank in their profession, have failed to diagnose even cases which had advanced far beyond the first stage. Formerly medical students were taught next to nothing about leprosy which was looked upon as an infirmity rather than a disease but in more recent years this has been remedied

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patient's eyes open, touching different unaffected parts of the body. When he is responding well to each touch, close his eyes by depressing the upper lids with the index finger and thumb of the left hand. Continue touching areas of normal skin to make sure that the patient still responds. Then touch the suspected areas, when failure to respond will indicate anæsthesia to light touch. To avoid error this should be repeated, the normal skin being used as a control. In this way anæsthetic areas may be mapped out. Definite anæsthesia to light touch is one of the cardinal signs of leprosy other conditions in which it is present are mentioned under DIFFERENTIAL DIAGNOSIS.

If anæsthesia to light touch is absent or doubtful, test for *analgesia* as follows blindfold the patient take two pins of the same size and sharpness, one in each hand prick the skin inside the suspected area, and simultaneously using equal pressure prick the skin either immediately outside the area or at the corresponding point on the other side of the body Ask the patient which is the more painful. By repeating the test several times with slight changes in the position of the pricks, differences in pain sensation can be elicited with a fair amount of accuracy

Heat and Cold Sensation can be tested similarly by touching the skin with test tubes containing hot and cold water and questioning the patient regarding the temperature.

Hyperæsthesia may sometimes precede anæsthesia to light touch, as may also thermal anæsthesia. When either of these appears it may be possible to make a tentative diagnosis and keep the patient under observation till definite signs appear

Paræsthesia may be present. The patient instead of pointing to the exact spot that has been touched, points to a part at a short distance from that spot. This indicates that while the direct sensory nerve-supply of the affected area has been blocked or destroyed the overlapping collateral supply is still acting so that the patient locates the sensation in the collateral area. For this reason such paræsthesia is commoner towards the circumference than in the centre of an anæsthetic area.

It is important to keep a record of lesions, and these may conveniently be plotted out on charts as in *Fig* 9

Areas having anæsthesia to light touch are shaded with vertical lines, and hypopigmented areas with horizontal lines. The width of the margin of leprides is indicated. Lepromatous areas, whether diffuse or macular are shaded in with dots, and each nodule is marked with an O varying in size with that of the nodule.

Ulcers are marked with crosses according to size, and deformed digits are marked with curved lines placed below these digits Thickened nerves are indicated by lines as in the chart.

Bacteriological examination results are marked on the side of the chart, indicating the site from which the material was taken and, if positive, the degree of positivity (see p 221)

Other important points are noted under Remarks or on the side of the chart.

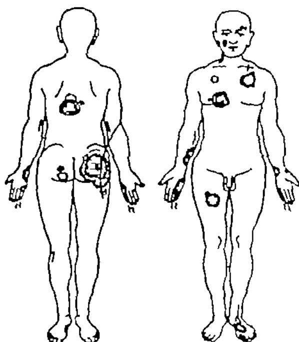


Fig. 9.—Chart for recording the condition of lepers.

THICKENING AND TENDERNESS OF NERVES

Small nerve branches supplying affected skin may sometimes be felt on palpation, or the main nerve may be thickened and tender If the suspected skin is struck sharply with the finger or the side of the hand or with some blunt instrument, tenderness or shooting or tingling pain may be elicited this being absent when the corresponding area on the other side of the body is struck

The following nerves are affected in this order of frequency The ulnar just above the elbow the superficial peroneal to the medial side of the head of the fibula behind the knee the radial as it curves round the humerus, or its branches as they pass over the lower end of the radius the posterior tibial inferior

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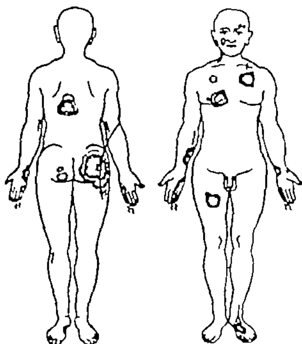


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to the inner malleolus the great auricular as it runs parallel to and behind the external jugular vein superficial branches of any nerve supplying a tuberculoid lesion. In the case of a doubtful thickening of a main nerve compare with the other side.

With the possible exception of one very rare condition (p 226) there is no other disease but leprosy in which there is definite thickening and tenderness present together so this is an important diagnostic sign. Though a clear diagnosis can often be made on clinical findings alone examination of a smear taken from a nerve may occasionally be necessary (*see* p 221)

BACTERIOLOGICAL EXAMINATION

It is important, as a rule, to make a bacteriological examination of the skin and/or of the nasal mucosa in all cases in which there are lesions suspicious of leprosy though a clear diagnosis can often be made on clinical findings alone.

Examination of the Skin and Nasal Mucous Membrane.—In tuberculoid macules, except in the reacting major form, bacilli are difficult to find they should be looked for at the margins of the macules. It is useless to examine anæsthetic areas of the acroteric type. In macules of the lepromatous type, and in diffuse infiltration and permanent nodules, bacilli can generally be found in large numbers. When there is no outstanding lesion the lobule of the ear is the place of choice.

Various methods of obtaining material for examination of *B lepræ* have been suggested, such as lymph-node puncture, or aspiration of fluid from blisters raised by CO_2 snow or other escharotics. We recommend as the standard method the examination of smears taken direct from the skin and the mucous membrane of the nose. If these are negative, other procedures are not likely to give positive results.

1 *Taking the Skin Smear*—Smears may be taken from the skin by either the snip or the scraped incision method. The former is slightly more thorough than the latter but it is more painful, leaves a scar and cannot be repeated as often as the latter without serious inconvenience to the patient.

Snip method After cleaning and compressing the part, a small piece of skin is removed with a scissors curved on the flat or with a sharp scalpel. The cut must be deep enough to draw blood. The material taken is either rubbed (raw surface down) on the slide, or the pulp is scraped off the epithelium with a knife and smeared on the slide.

Scraped incision method described by Wade and Rodrigues (1927) as follows Pinch up the skin in a fold applying enough compression to stop or minimize bleeding When it cannot be actually picked up compress it laterally as much as possible With a properly cleansed scalpel of suitable style and size, make a small but real cut 5 mm or so long and deep enough (about 2 mm.) to get well into the infiltrated layer If blood or lymph exudes in any quantity wipe it off With the knife-blade turned transversely to the line of the cut, scrape the side and bottom of the cut repeatedly and with sufficient vigour to obtain a little actual tissue pulp from below the epidermis. With the knife transfer the small amount of material obtained to a microscopic slide and make a uniform moderately thick smear over a small area

Whichever method is used, compression with a small piece of cotton-wool is generally sufficient to stop the bleeding otherwise wool with friar's balsam may be applied.

The *selection of the site to be examined* is important. The most marked and indurated lesion or part of a lesion should as a rule be chosen, such as a nodule or the raised margin of a macule. In cases with diffuse infiltration and with no outstanding lesion, the edge of the lobule of the ear may be conveniently chosen, as this is a particularly common site of infection and is easy to hold between the finger and thumb while taking the material.

The skin should be thoroughly rubbed with alcohol or ether before taking the material, not only to render it aseptic, but also to remove any saprophytic acid fast bacilli that may be lying on the surface. The knife or scissors should be flamed before a second use, as acid fast bacilli may adhere to the blade and are not necessarily removed at once by wiping or boiling We have repeatedly seen mistakes made by neglecting this precaution.

When the lepromatous type is suspected failure to find bacilli in one smear does not justify a negative diagnosis When necessary multiple smears should be made taking material from different sites. Several smears may be made on one slide, a note being kept of the part from which each was taken It must be remembered that the number of bacilli varies considerably in different cases so that while in one smear massive infection may be found, in another the whole slide may show only a few bacilli It is well to make smears of standard size and thickness, so that the degree of infection may be at least roughly estimated.

2 *Taking Material from the Nares*—The examination of the nasal mucous membrane is almost as important as that of the skin It occasionally gives positive bacteriological findings when

the skin is apparently negative (p. 152) A thin sharp-pointed instrument (such as a tenotomy knife) is used. Material should be taken from the septum or the inferior turbinated bone. If there is an ulcerated surface, slight scraping is sufficient otherwise a small piece of mucous membrane should be scraped off. In cases improving under treatment it may be necessary before declaring the nose negative to anæsthetize the mucosa and, using a speculum, to remove material from the upper part of the septum at least 1½ in. above the orifice. A cotton swab should not be used in making the smear as saprophytic acid-fast, or partially acid fast, organisms are frequently present on the surface of the mucosa, and have not infrequently been mistaken for *B lepræ* If a sharp instrument is used and a small piece of mucosa removed, this mistake is less likely to occur

3 *Staining Slides* (*Ziehl Neelsen Method*) —

a. Fix with heat, taking care not to char the smear

b Use the following stain —

Basic fuchsin	1 part	Grind thoroughly with pestle in mortar
Alcohol (95 per cent)	10 parts	
Solution of carbolic acid (1 in 10)	90 parts	

Place on the slide a square of filter paper large enough to cover the smear or smears and pour the stain on to the filter paper This prevents its spreading on the slide. Heat till it steams and allow it to remain for 10 minutes or stain cold for 30 minutes to 1 hour taking care the stain does not dry

c Decolorize for a few seconds with a 10 per cent solution of strong sulphuric or nitric acid in water The material becomes yellow

d. Wash well with water The material regains a faint pink tint. If the colour is distinctly red the decolorization is insufficient and acid must be reapplied.

This process should be repeated till only a slight red tint remains. It is well sometimes to stain two slides decolorizing the one more than the other This ensures that in one slide at least only the *B lepræ* remain stained and partly acid fast saprophytes so often present in nasal smears are eliminated. In the other slide the *B lepræ* will retain a brighter colour and more are likely to appear Finally wash well in water to remove all acid. It must be remembered that leprosy bacilli are less acid-fast than tubercle bacilli.

e Contrast stain with a saturated watery solution of methylene blue for 2 or 3 minutes.

f Wash well with water and dry

3 Examine under the microscope either directly or after mounting with acid free Canada balsam

4. *Examination of Slides*—In searching for bacilli an oil immersion objective and a fairly low ocular should be used a higher ocular being substituted if necessary for further examination of doubtful organisms

At least 100 fields should be examined before a slide is declared negative. A convenient way to denote the degree of infection is to write the largest number of bacilli in any field as the numerator and the number of fields examined as the denominator If more than 10 bacilli are found in any field then write M as numerator Thus $\frac{5}{1}$ = 5 bacilli was the largest number found in any field $\frac{M}{1}$ = more than 10 bacilli were found in at least one field $\frac{3}{50}$ = 3 bacilli were found in searching 50 fields. In this way a rough record can be kept of the progress of the patient at successive examinations. It is also useful to note whether bacilli are found in clumps or only singly and if granular or only partly stained forms are present

5. *Histological Examination*—The examination of sections of skin and subcutaneous tissue obtained by biopsy may be resorted to in some doubtful cases, though this is seldom necessary For the purpose of diagnosis it is only justified in cases in which bacteriological examinations are negative and the clinical signs are doubtful. In such cases there is as a rule to be seen in sections of the skin little that is clearly pathognomonic of leprosy as compared with other skin diseases. In slight lesions the principal feature which distinguishes leprosy from other diseases is the infiltration of the nerves, and it is important therefore to examine deep sections containing subcutaneous tissue and to examine especially the subcutaneous nerves for signs of granuloma.

6 In cases with doubtful thickening of a superficial nerve, and in which a clear diagnosis cannot otherwise be arrived at, it may be advisable to examine a *nerve smear* Cut down on the nerve, incise the epineurium longitudinally then with the sharp point of a knife gently scrape the bottom of the incision and tease out on a slide the few strands of nerve fibre thus removed. If the case is one of leprosy acid fast bacilli may be found lying on and between the fibres.

SUBSIDIARY DIAGNOSTIC SIGNS

Anidrosis.—In very chronic cases absence of the sweat function in the distal parts of the extremities is very characteristic of leprosy and in combination with other signs may confirm a diagnosis It

is often preceded by hyperidrosis. Patients with anidrosis of the whole skin area of the four limbs, or of a considerable part of that area, commonly complain of hyperidrosis of the rest of the skin surface, the sweat function being stimulated to compensatory activity (*see Fig.* 49). Anidrosis is also usually present in leprides (*see Fig.* 50).

In very early and doubtful macules, when a diagnosis of leprosy is doubtful, the pilocarpine test may be used to test for leprosy. A 1–1000 solution of pilocarpine (0·2 c.c.) is injected intradermally in the suspected patch and a similar amount in healthy skin. Both areas are painted with tincture of iodine and when this has dried are powdered with starch. The control area sweats and the iodine turns the starch blue, while absence of sweat round the injection spot in the suspected patch indicates leprosy. (Muir, 1939.)

Parakeratosis, Hyperkeratosis, Ichthyosis, Loss of Hair.— The first three of these conditions are due to malnutrition of, and certain changes in the horny layer of, the cuticle. There is a shiny appearance of the surface of the skin, often accompanied by the appearance of scales. The stratum corneum is not of its usual smooth elastic consistence; the cells retain their nuclei and adhere to one another, so that they are not shed individually but as scaly masses. Hyperkeratosis is best seen on the palms of the hands and soles of the feet, where the epithelium becomes abnormally thick and is apt to crack, sometimes resulting in perforating ulcer.

These changes in the stratum corneum are not confined entirely to the surface of the skin. The corresponding layer which penetrates the hair follicles is also affected; the hairs become soft and thick, and break off at their points of emergence from the surface of the skin. The broken end may become club-shaped and, as growth still continues inside, the hair becomes bent up inside the hair follicle. Similar changes also take place with regard to the nails, which become thickened and curve over the ends of the fingers in a manner similar to bird's claws (pp. 179 and 199).

Loss of hair of the beard and the eyebrows and even alopecia of the scalp are also well-known signs in lepromatous leprosy. (*See Figs.* 18, 33, 87.)

The scars of once active leprosy may show on the body long after the disease has apparently or actually disappeared. These may be recognized as large depigmented patches, scars of old nodules, and various deformities (*see Figs.* 53, 56).

Histamine Test (Rodrigues, 1933).—This, like the pilocarpine test mentioned above, is of use in very slight or early cases in which a

definite diagnosis cannot be arrived at. A drop of a 1–1000 solution of histamine is placed within the margin of the suspected skin area and a second drop outside the margin A prick is made with a needle through each drop deep enough to pierce the epithelium without drawing blood The histamine is wiped off In a short time a flare appears round the prick on the normal skin, but there is no flare on a leprous macule. This test is of chief value on a white skin as the flare is difficult to distinguish on a dark skin

DIFFERENTIAL DIAGNOSIS

Diseases from which leprosy has to be differentiated may be divided into three categories (1) Those resembling leprides (2) Those which may be mistaken for secondary neural (polyneuritic) lesions (3) Those similar to lepromatous leprosy

1 Conditions to be Differentiated from the Neural Leprides.—

a. Psoriasis.—Sensory changes are absent. Removal of scales leaves small bleeding points. Depilation and anidrosis are absent. Skin sections show a different histological picture (*See Fig* 58)

b Tinea.—Various forms of ringworm have to be differentiated The presence of the fungus and the absence of sensory and other neural changes generally make the diagnosis easy except in very slight lesions. Irritation of the skin, though sometimes present in leprous lesions, is as a rule much more marked in ringworm. Tinea is a very common complication of leprosy and lesions of the two diseases often lie side by side or even overlap *Tinea versicolor* and *tinea cruris* are the two commonest forms. (*See Figs* 42 44)

c Seborrheal Dermatitis—This has not infrequently been mistaken for leprosy especially by inexperienced persons who have, or fear they have, been exposed to leprous infection, and who have a tendency towards lepraphobia.

d. Syphilis—Syphilis may often closely resemble the macules and other lesions of leprosy The absence of sensory changes and the readiness with which the condition yields to treatment, generally make the differentiation easy It must be remembered, however that both diseases are not infrequently present at the same time, and that a positive serological test does not exclude leprosy

e Yaws—Yaws (framboesia) and its later development, gangosa, are not uncommonly mistaken for leprosy The absence of changes in sensation, of thickened nerves, and of acid fast organisms is sufficient to make the differential diagnosis and *Treponema pertenue*

may in early cases be found on microscopical examination. The old scars of yaws in the form of pigmented patches often closely simulate slight leprous lesions. Therefore in places where yaws is common a diagnosis of leprosy should not be made unless either definite *B. lepræ* are found in the skin or definite anæsthesia to light touch is present. The thickened skin of crab yaws may give a semblance of anæsthesia. The therapeutic test should always be used though very chronic cases of yaws do not always improve under treatment. (*See Figs* 72, 73, 74)

f. Dermal Leishmaniasis.—This has frequently been mistaken for leprides which it may sometimes closely resemble. Sensory changes are absent. When affecting the face it tends to concentrate round the nose and mouth. The macules are smaller and have less tendency to spread or to form a raised margin than those of leprosy. The history of having suffered from kala-azar or of having lived in an area where this disease is endemic, may be of value. The finding of Leishman-Donovan bodies will in many cases clear up the diagnosis. Here again both diseases are occasionally present at the same time. (*See* p. 227.)

g. Tuberculosis.—Lupus vulgaris is liable to be mistaken for a lepride. In both diseases a few acid-fast bacilli may with difficulty be found in smears or sections, and the histological examination of the skin shows certain characteristics in common. Lupus has generally, though not always, a greater tendency to scar formation than leprosy. The main point in differential diagnosis is the absence of nerve affection and sensory changes. In leprous macules resembling lupus the supplying nerves will almost certainly be affected.

h. Lupus Erythematosus.—Here again the absence of sensory changes and nerve thickening with negative histological findings, is sufficient to make the differentiation clear.

i. Leucoderma.—Leucoderma is in India and other countries sometimes mistaken for leprosy. Depigmentation is as a rule more complete and sensory changes are absent. It should be remembered that complete depigmentation of the skin is often found in the sites of healed leprous ulcers.

j. Injuries.—Burns and other injuries may leave anæsthetic scars. Anæsthesia may be caused by injuries to, or pressure on, nerves. We have not infrequently been consulted in such cases as to the possibility of leprosy.

k. Various dietary deficiencies, food poisons, etc. give rise to conditions liable to be mistaken for leprosy both on account of clinical appearances such as keratosis and discoloration and

because of doubtful sensory changes. Among these are pellagra and conditions similar to beri beri that are found in primitive peoples

2. Conditions to be Differentiated from the Anæsthetic Subtype of Neural Leprosy and Polyneuritic Lesions :—

a Syringomyelia etc.—The absence of nerve swelling and tenderness is important. Analgesia and loss of thermic sensation are accompanied by retention of sensation to light touch and the sweat function. The absence of other indications of leprosy and the presence of spastic signs and fibrillary tremors may help in differentiation

In one of our cases there was complete anæsthesia to superficial touch through the whole of the right upper limb but there were no other signs of disease in any other part of the body. There was also considerable paresis of the affected limb. The disease had begun proximally and had gradually spread down the limb within two or three months of the first symptoms being noticed. There was no marked wasting of the small muscles of the hand. Here it was obvious that the loss of sensation and the paresis were not due to disease of the nerves within the region of the upper limb but to disease affecting the nerve-supply of the limb at some more central point. In further proof of this—there was no thickening of the ulnar nerve although the distribution of the ulnar nerve was blocked. It was therefore clearly not a case of leprosy

b Cervical Rib—Here X ray examination should clear up the diagnosis. Nerve thickening is absent. There is loss of tactile and thermic senses, but retention of pain sense

c Raynaud's Disease—This has often been confused with leprosy because of the trophic changes present. In a case of leprosy with gangrene of the digits resembling Raynaud's disease, there is very marked anæsthesia of the whole foot or hand whereas in the latter disease there is anæsthesia only of the gangrenous parts and pain is a much more marked symptom

d. Superficial glove anæsthesia has been found as a result of *diphtheritic neuritis*. The history and the absence of thickening of the nerves leave no difficulty in making the differential diagnosis.

e Tenderness of superficial nerves especially the ulnar due to *neuritis of septic origin* is not infrequently a cause of personal alarm to doctors and others engaged in the treatment of leprous patients. There is, however seldom thickening of the nerve nor is there anæsthesia and attention to some septic focus connected with the teeth, nasal sinuses, bowel, etc. will generally clear up the condition.

f Hypertrophic Interstitial Neuritis (Dejerine-Sottas Disease) — In this condition there is thickening of the nerves If it occurs in childhood it is generally connected with a family history though this may be absent in cases occurring first in adult life. The nerves most commonly affected are the ulnar internal cutaneous of the forearm, saphenous and superficial cervical. The thickening of the nerves may be so great as to render them conspicuous to the naked eye. Sensory and trophic changes are similar to those in nerve leprosy as there is atrophy of the distal segment of the upper limb with claw hand Club-foot and talipes cavus are described as occurring in the lower limb rather than the trophic ulcers and drop-foot so familiar in leprosy The diagnosis of neural leprosy is simple in cases in which anæsthetic macules are present. When these are absent and when bacteriological examination of scrapings from the thickened nerves is negative the differential diagnosis may be more difficult If doubt exists sections of a small thickened nerve-branch should clear up all doubt, as the pathology of hypertrophic interstitial neuritis is very different from that of nerve leprosy There is hypertrophy of the peripheral nerves and in the spinal ganglia Masses of tissue may be present, with or without nuclei, arising from Schwann's sheath. Associated changes may be found in the anterior horn cells and in the posterior columns of the spinal cord This disease is very rare.

g Neurofibroma.—Von Recklinghausen's disease may sometimes resemble leprosy in respect both of nodule formation and of nerve thickening Bacteriological examination of the nodules, however fails to show acid fast organisms, and there are no sensory changes such as are present in leprosy

h. Neuritis of the Lateral Femoral Nerve (Bernhardt's Syndrome) —This may result in sensory changes in the antero-lateral region of the thigh. The size of the affected area varies from a few inches to almost the whole length of the thigh. In slight cases there is a feeling of numbness and slight loss of epicritic sensibility In more severe cases there is a feeling of gnawing, burning or pricking and complete loss of sensation on light touch or pricking with a pin in the affected area There is no depilation or keratosis such as would be present if the case were one of leprosy The condition tends to yield to protein shock and other forms of pyrotherapy

i The deformities caused by yaws, chiggers, and gangosa may sometimes simulate secondary neural as well as other forms of leprosy The absence of anæsthesia and nerve thickening is the chief point of differentiation (*See Fig* 60)

3. The Differential Diagnosis of Lepromatous Leprosy — This must depend on finding the causal organism. *Dermal leishmaniasis* and *diffuse adenomata* may give appearances clinically indistinguishable from the lepromatous type (*see Figs* 28 29) and *blastomycosis* may have lesions superficially similar to those of leprosy

Eunuchism has often been mistaken for leprosy because of the absence of the eyebrows and the sleek, shiny appearance of the skin.

There are many other diseases from which leprosy has to be diagnosed from time to time. As is mentioned on p 197 the case of a patient expectorating purulent sputum full of lepra bacilli may be mistaken for one of advanced pulmonary tuberculosis In another case a short, coccus-like acid fast bacillus which somewhat resembled *B lepræ* was found in some lesions of the skin Saprophytic, semi-acid fast organisms found in nasal smears may give rise to a mistaken diagnosis of leprosy (p 220)

* * * * *

One not infrequently comes across cases in which a diagnosis cannot be clearly made and judgement has to be reserved All such cases should if possible be kept under observation, as, if the case is one of progressive leprosy either the lesions will disappear or they will reach a stage at which the signs are no longer doubtful, and new lesions will appear and clearly establish the diagnosis

DIFFERENTIAL DIAGNOSIS BETWEEN INFECTIOUS AND NON-INFECTIOUS LEPROSY

Until we are able either to cultivate the lepra bacillus *in vitro* or to inoculate it successfully in experimental animals, it will be impossible to make an absolute statement as to which cases are infectious and which are not. If however we hold that the bacillus of Hansen is the causal organism, inability to find this bacillus either in the skin or mucous membrane, after thorough and repeated expert examination can surely be considered a sufficient indication that the case is not an infectious one at the time

The importance of distinguishing between infectious and non infectious cases must be emphasized The custom exists in India and in many other countries of ostracizing the leper depriving him of his employment and condemning him to live apart from his fellow men Now most cases, when they are first capable of being diagnosed, have not become infectious or a danger to their associates, the diagnosis being made upon purely clinical signs

viz. the presence of anæsthesia, nerve thickening etc. but bacteriological examination being negative. Most neural cases are not infectious and will clear up if treated in time. If lepers are ostracized as soon as they are diagnosed to be suffering from the disease, there are two inevitable results —

1 Many patients will hide the fact that they are lepers as long as possible and avoid seeking medical advice until the disease has advanced to such a degree that it can be hid no longer In this way they will lose what chance they would have had of early treatment with the possibility of recovery while as the disease advances and becomes infectious they become a serious danger to their associates

2 Such patients as are diagnosed and are ostracized are at once placed at a disadvantage as regards their chance of recovery Being deprived of employment they are in many cases unable to obtain sufficient means of subsistence, while the worries of seeking a precarious livelihood for themselves and their dependants, and the mental distress caused by their position as social outcasts, create the most suitable conditions for the rapid development of the disease.

It is therefore imperative that the line of demarcation, as far as segregation is concerned should rest, not on the diagnosis of leprosy but on the differential diagnosis between the infectious and the uninfectious leper

If this standard is generally adopted and lepers can come forward in the early non-infectious stage for diagnosis and treatment, with assurance that they will not at that time be ostracized, isolated, or deprived of employment and that there is a likelihood of their recovery then much will have been done to solve the leper problem, and the source of infection will be lessened.

DIAGNOSIS OF THE PREDISPOSING CAUSES IN LEPROSY

When a case has been established beyond all doubt as one of leprosy only half the diagnosis has been made It is no less necessary to find out what is the predisposing cause. We consider that it is highly probable that in an endemic area less than half of those who are inoculated with the germs of leprosy develop the disease. It is probable that the majority of people are highly resistant to leprosy and when in normal health are able to withstand infection. Even in those who are naturally more susceptible the degree of health determines to a large extent the severity if not the type of leprosy When, therefore we find a patient in whom the disease

has developed and in whom it is still continuing to extend it is necessary to look out for some predisposing cause which has lowered the resistance of the body and made the attack of the lepra bacillus successful The principal causes of lowered resistance to leprosy are various complicating diseases certain physiological states, malnutrition and food poisoning climatic conditions social customs, and personal habits and disposition

1 *Complicating Diseases*—Any acute or chronic disease which weakens or debilitates the leprous patient has an important bearing on his chance of recovery Among the more common complicating diseases are malaria, dysentery septic infections helminthic infestations, acute fevers, and venereal diseases. While the more obvious diseases are easily diagnosed the physician has to keep a careful outlook for insidious chronic conditions such as afebrile malaria filaria, ankylostomiasis chronic dysentery with its sequel constipation, thyroid deficiency and mycotic and septic skin diseases which are mistaken for manifestations of leprosy

An intercurrent disease not infrequently appears to ameliorate the signs of leprosy nodules and other lepromata flattening out and becoming less conspicuous The apparent improvement is probably due to the weakening of the patient and the consequent reduction of tissue reaction to the presence of bacilli This is borne out by the fact that convalescence is accompanied by an exacerbation of the signs of leprosy

Syphilis has been mentioned under DIFFERENTIAL DIAGNOSIS but not only has syphilis to be distinguished from leprosy—the two diseases may be present together Positive complement fixation and precipitation tests, though valuable in indicating complicating syphilis cannot be entirely relied upon as leprosy alone, especially the advanced lepromatous type, may sometimes give a positive Wassermann or Kahn test In former days syphilis was often mistaken for leprosy and this confusion may possibly be due in part to the frequency with which syphilis precedes leprosy as a predisposing cause, though recent investigations have shown that syphilis is not more frequent in those with leprosy than in the general population.

2 *Physiological States*—Such states as puberty pregnancy lactation, and the climacteric are well known to weaken resistance to leprosy It is commonly during these periods that the first signs appear or if the disease already exists that it becomes aggravated.

3 *Malnutrition and Food Poisoning*—These are most important predisposing and accompanying conditions in leprosy They

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be due to improper diet, bad digestion, or defective absorption. Badly preserved and partly decomposed fish was considered a very potent exciting cause in leprosy by Hutchinson (1897). Starvation is undoubtedly a predisposing cause in leprosy as it lowers the resistance of the body In Bengal leprosy is most rife in the Bankura district where famine conditions are much more common than in the other districts A famine year is followed by a marked increase, as owing to want of proper nourishment, the disease rapidly develops in the infected. There is, however a very marked increase in the death rate of pauper lepers, as charity is scarce in years of want.

On the other hand, *laziness* and *over-eating* are probably responsible as predisposing causes among the wealthy upper classes in India. In one case the son of a wealthy landed proprietor had led an active life as an engineer till he was forty years of age, when his father died On his succeeding to the landed property and considerable wealth, he gave up his active habits and began to lead a more or less leisurely sedentary life. It was probably in consequence of this sudden change from active to leisurely habits that within two or three years he showed signs of leprosy and the disease spread rapidly over the whole body (*See also* p 52)

4 *Climatic Conditions* —Climate is of importance, as extremes of heat or cold accompanied by moisture tend to produce a severe form of the disease A moderately dry temperate climate is most favourable. Santra has observed that when lepers accustomed to the dry hot climate of Rawalpindi migrate to the colder and moister climate of Kashmir they tend to take on a more severe lepromatous type, the reverse being the case in those who migrate in the opposite direction Moreover while leprosy is uncommon on the plains of the Punjab it is common on the adjacent Himalaya Mountains At the Ngomohuru settlement in Southern Rhodesia treatment results are obtained considerably more favourable than those in other similar African institutions. During the past ten years the disease in 53 9 per cent of the 1452 cases admitted has become arrested, and only 69 (8 8 per cent) of the arrested cases are known to have relapsed These results are the more remarkable as a considerable proportion of the arrested cases were of the lepromatous type. As the treatment in this place is similar to that in many other institutions the better results are apparently the result of the very favourable, equable, yet stimulating, climatic conditions in this particular locality Lowe and Chatterji have shown that the number of cases of the

neural type coming for treatment in Calcutta is greater in the hot than in the cold months of the year also during the hot season many who were formerly found bacteriologically negative become positive. These observations show that climate may have an important effect on leprosy (*See* Chapter II and p 246)

5. *Social and Sanitary Customs* often predispose to and aggravate leprosy Examples of these are the joint family system in India, often leading to overcrowding and insanitary conditions and various superstitions and taboos of primitive tribes, such as those forbidding the use of meat milk, eggs, and other useful articles of diet (Santra, 1930)

6 *Personal Habits and Disposition* are of the utmost consequence Laziness irregular habits, self indulgence lack of perseverance or a pessimistic outlook on life—any one or more of these may be sufficient to determine the future course of the disease. The mental equipment of the patient especially his intelligence and determination are of particular importance in a disease in which treatment has to be maintained for years, and should be carefully assessed before determining the treatment. (*See* MENTAL CONDITION p 205.)

The *blood sedimentation test* is of considerable value in assessing the general health of the patient, as it is also in ascertaining his tolerance of special treatment (*see* p 251) Accelerated sedimentation, though often the result of activation of leprosy may also denote that one or more of the above mentioned predisposing causes is present and must be found out and if possible eliminated (*see* p 251) The *plantar hyperesthesia test* may also be useful in the same direction (p 190)

CHAPTER XVI

PROGNOSIS

Importance of Prognosis.—The prognosis in leprosy is of special importance because of the dread that the disease inspires. It is not the fear of death that induces this dread but rather the fear of a long-drawn-out miserable existence. Leprosy may be a very slight passing ailment, or it may be one of the most horribly disfiguring and loathsome diseases. Naturally the patient and his friends are very anxious to know what the prospects are. Considerable experience is necessary before making a confident prognosis. As there is no evidence that there are different strains of *B. lepræ* varying in virulence, there remain two important factors to be estimated: the concentration and distribution of the bacilli in the body and the resistance by the patient to the infection.

The Type of Leprosy.—The prognosis is much more favourable in the neural than in the lepromatous type. The bacilli are far fewer in number and the resistance, as shown by the greater relative response of the tissues to these few bacilli, is considerably greater. Even a patient with widespread and conspicuous tuberculoid lesions must be considered a more favourable case than one with early slight lesions of a distinctly lepromatous type. In the neural type there is a definite tendency towards localization and confinement of the infection to one or more nerves and limited skin areas. The majority of such cases, provided good health can be secured, are likely to recover either spontaneously or much more rapidly with the help of special treatment.

The prognosis is much less favourable in cases of the lepromatous type. In these the disease tends to become diffuse. The lesions are at first less conspicuous as the conflict of the tissues with the invading bacilli is much less fierce. Here as in the neural type the maintenance of a high standard of general health is an all important element, but even in spite of good health and in some cases in spite of any special treatment yet available, the disease will continue to advance. On the other hand even some patients with advanced nodular lesions have been known to recover entirely under prolonged and carefully planned treatment (*see Figs.* 87, 88).

Extent and Progress of the Disease—The earlier a patient comes under treatment the more favourable is the prognosis Another important point is the history of the progress of the disease—whether it is advancing slowly or rapidly whether it is stationary or is resolving It is easier to assess the progress of the neural type lepromatous cases are liable to show temporary appearances of pseudo-improvement It is often wise to watch the response to general and special treatment before venturing on a prognosis, as some patients respond much more favourably than others. Often the most favourable outlook is in those suffering from some definite debilitating disease or other condition which can be entirely and permanently removed Spectacular results are often seen in patients with tuberculoid lesions These may be widespread and prominent, almost resembling a severe nodular case but showing only a moderate number of bacilli yet, with or without treatment, they may clear up rapidly within a few weeks or months leaving only slight scar formation (*see Figs* 53, 56)

Factors Influencing Resistance.—These have been more fully discussed in the previous chapters but are again summarized here as no reliable prognosis can be made without assessing the patient's resistance. They are the unknown factor discussed under IMMUNITY in Chapter IX, which prevents even debilitated contacts from developing the disease at all or at least the lepromatous type the general health of the patient, and all the internal and external elements which influence its improvement or deterioration, including the condition of the patient during puberty or pregnancy (*see discussion at the end of Chapter XV*) and the age factor

The Age Factor—It has been shown in Chapter VI that susceptibility varies with age. *Table VII* shows that the onset took place in approximately 50 per cent of cases before twenty years of age, and 67 per cent before twenty five. Lowe and Dharmendra found that the lepromin test gives a weaker reaction in younger than in older non-contacts (p 156) which suggests that there may be less resistance to *B lepræ* in the earlier years of life. Marchoux and Chorine (1937) argue that the greater susceptibility of young children is dependent not on greater physiological susceptibility but on their thinner skin and their closer and more constant contact and *therefore a more concentrated infection when* the parent or guardian is a leper

The neural type indicating comparatively strong resistance is common in children of school age in endemic areas as shown by school surveys (p 44) The prognosis in such cases is generally good and clinic treatment results in complete recovery

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The Age Factor—It has been shown in Chapter VI that susceptibility varies with age *Table VII* shows that the onset took place in approximately 50 per cent of cases before twenty years of age, and 67 per cent before twenty five. Lowe and Dharmendra found that the lepromin test gives a weaker reaction in younger than in older non-contacts (p 156) which suggests that there may be less resistance to *B lepræ* in the earlier years of life. Marchoux and Chorine (1937) argue that the greater susceptibility of young children is dependent not on greater physiological susceptibility but on their thinner skin and their closer and more constant contact, and therefore a more concentrated infection when the parent or guardian is a leper

The neural type indicating comparatively strong resistance is common in children of school age in endemic areas, as shown by school surveys (p 44) The prognosis in such cases is generally good and clinic treatment results in complete recovery in the

CHAPTER XVI

PROGNOSIS

Importance of Prognosis.—The prognosis in leprosy is of
ecial importance because of the dread that the disease inspires.
is not the fear of death that induces this dread but rather the
ar of a long-drawn-out, miserable existence. Leprosy may be
very slight passing ailment or it may be one of the most horribly
sfiguring and loathsome diseases Naturally the patient and
friends are very anxious to know what the prospects are
onsiderable experience is necessary before making a confident
ognosis As there is no evidence that there are different strains
B lepræ varying in virulence, there remain two important
ctors to be estimated the concentration and distribution of the
cilli in the body and the resistance by the patient to the
fection

The Type of Leprosy—The prognosis is much more favour
le in the neural than in the lepromatous type. The bacilli are
fewer in number and the resistance, as shown by the greater
ative response of the tissues to these few bacilli, is considerably
eater Even a patient with widespread and conspicuous tubercu-
d lesions must be considered a more favourable case than one
th early slight lesions of a distinctly lepromatous type. In the
ural type there is a definite tendency towards localization and
nfinement of the infection to one or more nerves and limited
n areas The majority of such cases, provided good health
n be secured, are likely to recover either spontaneously or much
ore rapidly with the help of special treatment.

The prognosis is much less favourable in cases of the lepromatous
pe. In these the disease tends to become diffuse. The lesions
e at first less conspicuous, as the conflict of the tissues with the
vading bacilli is much less fierce. Here as in the neural type
e maintenance of a high standard of general *health is an all*
portant element but even in spite of good health and in some
ses in spite of any special treatment yet available, the disease will
ntinue to advance On the other hand even some patients
th advanced nodular lesions have been known to recover entirely
der prolonged and carefully planned treatment (*see Figs* 87 88)

Extent and Progress of the Disease.—The earlier a patient comes under treatment the more favourable is the prognosis. Another important point is the history of the progress of the disease—whether it is advancing slowly or rapidly whether it is stationary or is resolving It is easier to assess the progress of the neural type lepromatous cases are liable to show temporary appearances of pseudo-improvement It is often wise to watch the response to general and special treatment before venturing on a prognosis, as some patients respond much more favourably than others. Often the most favourable outlook is in those suffering from some definite debilitating disease or other condition which can be entirely and permanently removed Spectacular results are often seen in patients with tuberculoid lesions These may be widespread and prominent almost resembling a severe nodular case, but showing only a moderate number of bacilli yet, with or without treatment, they may clear up rapidly within a few weeks or months leaving only slight scar formation (*see Figs* 53 56)

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The neural type indicating comparatively *strong resistance*, is common in children of school age in endemic areas, as shown by school surveys (p 44) The prognosis in such cases is generally good and clinic treatment results in complete recovery in the

great majority but in children with the lepromatous type the prognosis is particularly bad, worse on the whole than in adults with the same type

The Danger of Contacts.—Not infrequently those who have been in contact with leprosy are anxious to know the likelihood of the disease showing itself The factors which determine the danger of contact are its closeness and duration, the infectiousness of the case and the age and general health of the person exposed to contagion Thus a debilitated adult or a young child may occasionally acquire the disease after even short or slight contact with a highly infectious case Undoubted cases are also known where dwelling in a house vacated by a leper or the use of furniture formerly used by a leper has been followed by the appearance of leprosy Either leprosy is far less communicable than tuberculosis, or the resistance of the average population is far greater For one or both of these reasons the former disease in an endemic form died out of England centuries ago while the latter is still prevalent In making a prognosis the *lepromin test* may be of value, as a strong reaction may indicate vigorous resistance, and that even if leprosy did develop it would probably be of a mild type. (*See* Chapter IX.)

Recovery with or without Deformity—Early neural cases may be expected to recover with little or no deformity provided their general health and environment are good. The same is true of the more advanced neural cases but they require a longer period of treatment and the degree of deformity remaining is likely to be greater In lepromatous cases the prognosis is more uncertain and good health and environment are of even greater importance. Also much depends on the intelligence and perseverance of the patient and the skill and experience of the physician. Secondary neural lesions frequently appear in advanced lepromatous lesions and increase in severity as the infection diminishes, and in the end infection may almost or entirely die out, leaving deformities of the face and extremities In arrested lepromatous cases, even when active signs have been absent for years a guarded prognosis should always be given, as complete elimination of infection cannot be ensured and relapse is always possible if the patient's health deteriorates at any future time. On the other hand, should the patient in such an arrested case sustain a severe illness without return of signs of leprosy then a much more confident verdict might be given

It is an important matter for the patient whether there will be permanent deformity or not. From his point of view recovery

is of comparatively little value if he d... him abhorred by the community ... engaging in work The earlier the p... rapidly he recovers, th... also can be done to prevent d... regulated exercises

Causes of Death.—Leprosy differs from ... tuberculosis in its low mortality Pat... tions, and many of these result from neglect ... ostracism and the helplessness of crippl... itself may cause death in a minority ... in obstruction of the larynx or ... longed lepra fever In some places tuberculosis is a common cause of death another being renal d... chronic gastric or intestinal inflammation and marked ... anæmia often precede death In neglected ... conditions of the feet hands or nose may lead to a fatal result or absorption from chronic ulcers by producing amyloid degeneration of the internal organs may indirectly lead to death

Duration.—The duration of leprosy is very variable In neural cases when the disease is definitely limited and confined to a few small lepride these will often clear up under suitable treatment in a few months Without such treatment they may persist or spread indefinitely When leprosy is an acute febrile disease its duration may be comparatively short the patient dying of toxæmia exhaustion, or some intercurrent disease within two or three years Such cases are however rare and with proper treatment and nursing would probably not occur As the incubation period may extend from a few weeks or months to thirty or forty years it stands to reason that there are the greatest possible variations in the duration of the disease itself

Seeing that probably over 50 per cent of cases are infected before the age of 20 and that although in many cases the disease becomes permanently arrested it is impossible to say that all the bacilli have disappeared from the body it must follow that in a considerable number the duration of the disease must be lifelong

Duration is largely influenced by climate food sanitatic habits of the patient coexisting and intercurrent diseases patient's social and economic position and the skill and care which he is treated and nursed.

absorbing tubercles on the face without scarring or pigmentation. When available, it may be used in slight cases with limited lesions

Electrical Currents.—Diathermy is of considerable value in neural cases with thickened and tender nerves of the extremities but considerable skill and care are necessary in applying the electrodes and regulating the current, otherwise nasty ulcers are apt to be caused. The galvanic current may also relieve pain and the faradic current may be of use for partially atrophied muscles

3. VACCINES, SERA ETC.

Autogenous Vaccines have been used by many workers but most of them have only treated a few cases Some have ground up lepromatous material and injected a heat killed emulsion. Some have treated nodules with antiformine so as to obtain the bacilli as free as possible from tissue material. Hasson and Little reported excellent results in cases injected with a suspension obtained from blister fluid after application of carbon-dioxide snow One drawback of this form of treatment is the difficulty of obtaining sufficient material, as this can only be got from advanced lepromatous cases. In such cases auto-inoculation with lepra bacilli can much more easily be induced by oral administration of minute doses of potassium iodide though, as mentioned above, this form of treatment is not recommended except in carefully selected cases, and it must always be carried out with great care.

Lowe and Dharmendra using refined lepromin (suspension of lepra bacilli separated from tissue debris and lipoids) attempted without success to change a weak positive or negative lepromin reaction (p 157) into a stronger or positive one by repeating the test at monthly intervals up to 18 months In only 2 of 62 lepromatous cases, and 8 of 27 neural cases was there a slight increase

Tubercle Bacilli and Tuberculin.—Tuberculin has been used in leprosy because of the resemblance of the bacillus of tubercle to that of leprosy Lie got encouraging results with small doses, but most of the other reports are adverse Row used suspensions of autolysed cultures of tubercle bacilli washed free from fatty substances with petrol ether He and others reported favourable results. Calmette-Guérin antigen was not found to give lasting improvement.

Other Acid-fast Organisms—The most widely known preparation was that of Deycke. This consisted of a killed suspension of an acid fast organism cultivated from a leprous nodule. A

mixture of this and benzyl chloride was called *nastin B* Numerous reports appeared of favourable results, but the majority of those who tried it obtained no permanent improvement Several other vaccines prepared from acid-fast organisms have been tried some under the belief that they were cultured *B lepræ* but results on the whole have not been encouraging

Protein-shock Therapy—Treatment of leprosy has been attempted by intravenous injection of various forms of bacilli both acid fast and otherwise, with the object of raising the temperature and breaking down nodules Milk and other forms of protein have also been similarly used Temporary apparent improvement sometimes follows but it is doubtful if the net end results justify this form of therapy

Sera and Autohæmotherapy.—Various attempts have been made to produce immune serum by injecting into horses and sheep material from lepers or supposed cultures of lepra bacilli Abraham and Herman injected a horse with fluid contents of nodules but obtained no improvement in the two cases treated. Laverde inoculated sheep and goats with the juice of nodules 60 patients injected with the serum of these animals are said to have shown improvement and 10 to have been cured Currie, Clegg and Hollmann used this culture in horses, but the serum obtained gave no promising results. Reenstierna repeatedly injected a culture which he regarded as one of *B lepræ* into sheep rapid and favourable action was claimed by those using the serum obtained from these sheep but there was no report of improved bacteriological condition Faget and Pogge, after using pooled blood plasma transfusions in 12 cases, considered that there is no evidence to indicate that non-specific blood-plasma has any value in the treatment of leprosy

Collier and others made extraordinary claims for the usefulness of diphtheria antitoxin and toxoid in clearing up lesions, but other workers have failed to get any improvement with this method

Claims have been made of relief of pain and improvement of eye conditions by intramuscular injection of the patient's own blood

Venom, Antivenom.—Gass obtained marked or considerable relief in 32 out of 35 cases of leprous neuritis treated with 1 to 3 mouse-units of cobra venom. Other workers have also reported favourably Dyer treated 5 cases with antivenom with marked improvement in 4, but Woodson after getting improvement in one case considered that the result was due to serum alone

4. CHAULMOOGRA AND OTHER OILS

Chaulmoogra or *hydnocarpus oil* has long been known as a remedy for leprosy in India and other countries. It is derived chiefly from the seeds of *Taraktogenos kurzii* from Assam and Burma *Hydnocarpus wightiana* from south-west India (*see Fig* 83) and *H anthelmintica* from Siam and Indo-China (*see Fig* 82) Recently *H wightiana* and *H anthelmintica* seeds have been planted in Nigeria, the Congo Fiji, and East Africa, and a limited amount of oil is available. Among the related oils is *sapucainha* obtained from *Carpotroche brasiliensis* native to Brazil.

Formerly chaulmoogra was used only by mouth or inunction, but during the last twenty five years better results have been obtained by injection. When injections were first given the oil then available was found to be painful and slow of absorption. Consequently various mixtures and emulsions were prepared with the object of reducing irritation and making absorption more rapid

Rogers* published in 1916 an account of treatment with sodium hydnocarpate and reported very favourable progress. He considered the lower melting point fatty acids of chaulmoogra oil hydnocarpic acid (up to 49 C.) to be more active than those of the higher chaulmoogric acid (68 C.) and such a preparation (under the proprietary name of Alepol) is still used Sodium hydnocarpate is soluble in water and can be given in solutions up to 3 per cent intravenously intramuscularly subcutaneously and intradermally Given intravenously it is apt to cause endophlebitis and obliteration of veins.

Macdonald in 1920, after confirming the earlier work of Rogers, reported *the use of ethyl esters of chaulmoogra oil prepared* by Dean, with very satisfactory results. Later these workers reported better effects from the hydnocarpic than from the chaulmoogric fraction of the oil. But later still, Rodrigues found the esters of the whole oil, iodized to make it less irritant, to be the most effective *He found creosoted esters almost as good. All* these preparations were made with the object of obtaining a substance of low irritation which would be tolerated when injected into the tissues.

It was subsequently found that the oil itself when expressed from ripe fresh seeds of *H. wightiana* or *H anthelmintica* was tolerated well the former irritant oil had been obtained from stale seeds

* For the history of the modern advance in the treatment of leprosy *see* Rogers, Cameron Prize Lecture, *Edinb med. J* 1930 37 Jan.

bought in the open market. The following statement was adopted by the International Leprosy Congress at Cairo in 1938 —

Hydnocarpus oil and its esters administered intramuscularly subcutaneously and intradermally remain, so far as our present knowledge goes, the most efficacious drugs for the special treatment of leprosy Oils from *Hydnocarpus wightiana* and *H anthelmintica* are most widely used The irritant properties of these drugs have been shown to be due to the decomposition products of their therapeutic constituents i e chaulmoogric, hydnocarpic, and gorlic acids. This decomposition takes place rapidly in the seeds, and hence it is necessary to use only oils pressed from fresh seeds. The oil itself is quite stable and keeps fairly well under proper conditions of storage. The ethyl esters are much less stable than the oil, and should be prepared and sealed hermetically against air as quickly as possible. Distillation of the esters and elimination of the free fatty acids is of less importance in the reduction of irritation than the use of an oil prepared from fresh seeds. The use of ampoules, where possible is recommended when bottles are used they should be of such size that the entire contents may be used on the day that they are opened. Any remaining drug should be used for local applications. Reheating of esters should be avoided.

Recently Flandin has reported promising results from a fine emulsion of chaulmoogra oil and cholesterol (B55) which can be given intravenously These results have not been confirmed

There are various theories as to how chaulmoogra oil acts in leprosy whether it is in virtue of its specific rotation, or its unsaturation as shown by its high iodine value It has been suggested that by stimulating lipase action it increases the lysis of bacilli. None of these theories has yet been proved. In *Table XXII* are shown

Table XXII —CHARACTERS OF CHAULMOOGRA AND ALLIED OILS

	Taraktogenos kurzii	*Hydnocarpus wightiana*	*Hydnocarpus anthelmintica*	*Carpotroche brasiliensis*
Melting point	2	22	24	13
Specific gravity	93 (24)	0·958 (25)	0 953 (25	0·5963 (5)
Specific rotation	+ 52·2	+ 57·7	+ 51·5	+ 51·2
Iodine value	03·0	3	8· 4	11 7
Saponif. value	204	—	—	198 8

Chaulmoogric acid Specific rotation 68 melts at 68 iodine value 90·
Hydnocarpic acid Rotation 68 1 melts t 59, iodine value 100·2
Oncoba echinata, African plant of same family yields chaulmoogric acid to extent of 87·5 per cent of its fatty acids.

some of the physical and chemical characters of the more important oils of this group

Other Oils—In accordance with the theory that the unsaturated fatty acids of chaulmoogra oil (iodine value 90·7 to 104) form the chief therapeutic factor various other oils of high iodine value have been tried. Chief among these are cod liver oil (iodine value 154 to 181) linseed oil (iodine value 173 to 201) and soya bean oil (iodine value 137 to 143) Trials of these oils have as a rule given results inferior to those with chaulmoogra oil but may sometimes be of use as alternative treatment for a time. Cod liver oil is sometimes injected along with chaulmoogra oil because of its vitamin value. Eucalyptol gurjun oil, and nim oil (*Melia azadirachta*) have each been tried without marked benefit Neff reported good results, especially in relieving nerve pains from injection of esters from dilo oil (*Calophylum inigator*) but others have obtained negative results

Degotte, working in the Belgian Congo found it difficult during the war to get supplies of chaulmoogra oil. He prepared oil of citronella from local plants and mixed one part with nine parts of cotton-seed oil to reduce its irritant properties. He injected this mixture in 1 to 6 c.c doses intramuscularly and intradermally He concluded after analysing the results in 2928 cases that oil of citronella is comparable in its effects with those obtained with chaulmoogra oil. Symptoms disappeared in 4·9 per cent using the former and in 4 4 of 3792 cases in which he used the latter

Recent Drugs under Trial.—

Diasone and Promin—These two synthetic drugs were first used in the treatment of tuberculosis. As reports were favourable, trials in leprosy were made in America and Trinidad. Faget and his colleagues reported that promin can be safely administered intravenously for prolonged periods provided the blood and urine are examined frequently When these precautions are taken toxic manifestations are relatively rare and mild. The most important of them, hæmolysis if recognized early is usually controllable and not a cause of discontinuance of treatment" The great majority of their patients under treatment received from 1 to 5 g daily for six days a week, Sundays excepted. Most of the patients were given the 5 g dose, and the treatment was continuous for months with only short intervals of rest of one to two weeks three times a year These authors state that after hæmolysis, the most important toxic reaction was the development of allergic dermatitis and that other manifestations were allergic rhinitis headaches, and nausea.

Muir (1944) gave diasone intravenously dissolving 0 3 gr of the powder in 1 c.c. of sterile saline and filtering through gauze. He gave smaller doses, 1 to 6 c.c. three times a week. In other cases he gave 1 to 2 5 g three times a week by mouth

The results obtained with both drugs were similar improvement of general health drying up of lepromatous ulcers, flattening of nodules, improvement in condition of the nose and eye. The results were most remarkable in patients in the second and especially in the third stage of the lepromatous type (p 204) In both drugs it is best to begin with small tentative doses and, as secondary anæmia is apt to be caused especially at the beginning of treatment, frequent red blood-cell counts or hæmoglobin tests should be made.

Asiaticoside—Grimes and Boiteau working in Madagascar obtained a glucoside from *Hydrocotyle* or *Centella asiatica* an umbelliferous plant growing on the island It is soluble in water and in pyridine and can be given by injection. Results obtained so far are said to be remarkable in clearing up ocular lesions and diffuse infiltrations, lepromas break down and scar up and perforating ulcers heal up (*Leprosy Review* 1945, 16)

Penicillin—Wharton (1945) reports useful results by giving a solution of sodium salt of penicillin to nine advanced lepromatous cases in British Guiana. The total dosage injected in each case was 400 000 units of four hourly doses of 50 000 units He concluded that while in this dosage there was no bacteriocidal or bacteriostatic effect on *M leprae* it is of definite value, especially in healing ulcerating nodules chronic ulcers and inflammatory eye conditions, and in controlling lepra reaction. It retards erythrocyte sedimentation and improves the physical and mental condition of the patient.

Streptomycin, obtained from a mould, *Actinomyces griseus* has, like promin and diasone, been found to exert a bacteriostatic effect on *M tuberculosis* We have no means of ascertaining if it has similar effects on *M leprae* but the close resemblance between the two mycobacteria suggests the trial of such drugs in the treatment of leprosy

CHAPTER XVIII

LINES OF TREATMENT RECOMMENDED

SUCCESS depends upon careful attention to each case. The best results are obtained by raising the patient's general health and resistance to the highest possible level and giving the maximum amount of the best available special treatment consistent with maintaining the general health. By *special treatment* we mean drugs to clear up lesions caused by the presence of *B lepra* by *general treatment* is meant all measures used against complicating diseases or lepra reaction and for improving and maintaining the general health. It is not intended to draw too fine a distinction between these two special methods when carefully regulated may often improve the general health by clearing up lesions and general treatment will often cause a marked improvement in the lesions On the other hand, special treatment, as for example by injection generally produces a temporary negative phase or lowering of the general health so that pressing this treatment beyond the tolerance of the patient is likely to be harmful The relative importance of special and general treatment varies in different cases. In strong healthy patients no general treatment may be necessary in weak patients suffering from malnutrition special treatment may have to be postponed for a period until the general health has been improved

GENERAL TREATMENT

Complicating conditions found in the original examination and others arising later have to be rectified as far as possible (*see* Chapter XV) In debilitated patients it may be months or years before special treatment can be tolerated because of reactions these cases tax the ingenuity of the physician.

Among the other important factors to be considered in general treatment are climate, nutrition, exercise, and the mental condition of the patient.

Climate.—Removal to a cooler or [illegible] climate [illegible] result in improved health, especial[illegible] like [illegible] which the heat regulating function [illegible] with. of both heat and cold are harmful. [illegible]

climate without excess of heat or cold When possible, patients should be sent to such a climate and when a site for a leper colony or hospital is to be selected a place with such conditions should if possible be chosen (*See also* pp 10–16 229, 230)

Nutrition.—As in tuberculosis and all other wasting diseases the diet of the patient forms a most important consideration in leprosy The waste of the tissues has to be made up and the resistance power of the body to be strengthened to destroy the attacking bacilli The object is not to be gained by feeding the patient up It is not the quantity of the food but its nature, proportion preparation, and freshness that make the difference Fresh vegetables, fruit, and dairy produce have a very important place The introduction of vegetable gardens and dairy farms with the proper rearing of cattle, and the substitution of fresh for preserved meat, had perhaps a most important place in the eradication of leprosy in England and other European countries Yeast and vitamin B preparations have been found useful in clearing up nerve pains and improving the general health Cod liver oil, combined where possible with ultra violet ray treatment, is beneficial in some cases 0 5 to 1 gr of thyroid daily at bedtime has changed the whole aspect of some cases but care must be taken in giving this drug Others suffering from hypochlorhydria show marked improvement on half an ounce per diem of dilute hydrochloric acid These are only examples of various factors which form the background of leprosy and without removal of which special treatment is not likely to be effective.

Exercise—An important part of general treatment consists in regulating the patient s daily time-table He should have suitable mental and physical occupation to avoid brooding and depression. Physical training is exceedingly important, but it should be progressive and carefully graduated as sudden taking of violent exercise by those unaccustomed may be harmful. Special exercises should be included to correct any trophic paresis and deformities Walking is one of the best exercises, but in those with a tendency to ulcers of the feet cycling may be substituted Work in the garden and in the field is excellent, and many of the deformities which render this impossible to the poorer patients would never have occurred if they had persisted in doing such work from the beginning It is generally found that patients with firm, well-formed muscles tolerate special treatment best and make most rapid progress towards recovery

As regards diet, exercise and regularity of habits the patient should go into training —he should seek to become an athlete.

Mental Condition.—Not less important is the treatment of the mental condition of the patient (p 205) Patients must be encouraged to exert their will power in the direction of getting better If any improvement is to be effected the co-operation of the patient is most important. There is much that the patient can do the taking of systematic exercise, bathing and friction of the body regular attention to diet and other rules which must be carefully laid down and explained to him by the physician

Patients of the early neural type should not be taken away from their ordinary work, provided suitable treatment and environment can be secured locally We have found that patients who are strong and well and able to carry on their work have much more chance of recovery since they are kept physically and mentally active, and are able to look upon themselves as ordinary patients suffering from a chronic disease which they hope to get rid of whereas, if they have to consider themselves as outcasts, untouchables and people to be shunned, their chance of recovery is seriously handicapped

The danger or otherwise of leprous patients continuing to mix with the public, and carrying on their usual avocations, is a matter which should receive the closest consideration of the physician, as well as of the patient and his friends and associates (see p 227) More advanced neural cases found not to be improving on outside treatment, especially if their environment is not favourable or if fear of public ostracism is causing them mental distress, are likely to find more relief and chance of recovery inside a modern leprosy institution.

Leper colonies and homes where those who are bacteriologically positive can continue to live a normal, busy life are, besides being effective in preventing the dissemination of infection extremely beneficial to the patient both mentally and physically (p 128)

It is seen from the above that to obtain the best results each case must be individually studied and the greatest medical skill and care are required

SPECIAL TREATMENT

In choosing the special treatment the best remedies and methods known at the time should be used. As a rule experimentation should be left to physicians with sufficient experience and proper facilities. The literature is full of accounts of experiments on two or three cases by doctors with little or no previous experience, and incapable of evaluating the results.

As already mentioned (p 243) the International Leprosy Congress in 1938 favoured injections of hydnocarpus (chaulmoogra) oil and ethyl esters prepared therefrom as the basis of special treatment. It is all important that a pure brand of this oil be obtained, otherwise it is irritant and is not tolerated by the patient.

Chaulmoogra Oil versus Esters.—The consensus of opinion is that the oil and esters are equally beneficial. The esters are less viscid easier to inject, and more rapidly absorbed The viscidity of the oil is lessened if 4 per cent creosote is added and if it is injected warm (45 C.) For intradermal injection its slow absorption is perhaps an advantage as the local effect is prolonged a benefit if several months are required to complete the infiltration of multiple lesions In patients with a tendency to keloid formation intradermal injections are less likely to cause this condition if oil is used for infiltration and not esters. The oil is more stable and when stored takes longer to undergo physical or chemical change and become irritant, especially if creosote has been added its cost is much less, a distinct advantage where large numbers of poor patients have to be treated. It is uncertain whether the oil or the esters is more effective if there is a difference it is not great. (*See* Appendix I)

Sodium hydnocarpate, though it is considered less beneficial than the oil or esters, has the advantage of cheapness and of being preserved in powder form It is given as a 3 per cent solution in water

Methods of Injection.—Which method—intramuscular subcutaneous, or intradermal—should be used depends on the type of case and the condition of the patient Sodium hynocarpate may be given intravenously but neither the oil nor the esters should be given by that route

Intramuscular injections can be given into any thick muscular mass, but the gluteus maximus is the muscle of choice Each dose should be divided not more than 1 c c. being injected at any one point. Divided injections may be given by partly withdrawing the needle and reinserting it at different angles. By warming the oil and injecting slowly and dividing the dose hard and painful lumps and abscesses may be avoided If an attack of coughing comes on during an injection, it is a sign that a vein has been pierced This infrequent accident may be avoided by first pulling on the piston to see if blood enters the syringe

Subcutaneous injections may be given under lesions occurring in fleshy parts of the body and especially on extensor surfaces

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The danger or otherwise of leprous patients continuing to mix with the public, and carrying on their usual avocations, is a matter which should receive the closest consideration of the physician as well as of the patient and his friends and associates (see p 227) More advanced neural cases found not to be improving on outside treatment, especially if their environment is not favourable or if fear of public ostracism is causing them mental distress are likely to find more relief and chance of recovery inside modern leprosy institution.

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It is seen from the above that to obtain the best results each case must be individually studied, and the greatest medical skill and care are required

SPECIAL TREATMENT

In choosing the special treatment the best remedies and methods known at the time should be used As a rule experimentation should be left to physicians with sufficient experience and proper facilities. The literature is full of accounts of experiments on two or three cases by doctors with little or no previous experience, and incapable of evaluating the results

As already mentioned (p 243) the International Leprosy Congress in 1938 favoured injections of hydnocarpus (chaulmoogra) oil and ethyl esters prepared therefrom as the basis of special treatment It is all important that a pure brand of this oil be obtained, otherwise it is irritant and is not tolerated by the patient.

Chaulmoogra Oil versus Esters—The consensus of opinion is that the oil and esters are equally beneficial. The esters are less viscid easier to inject and more rapidly absorbed The viscidity of the oil is lessened if 4 per cent creosote is added and if it is injected warm (45 C.) For intradermal injection its slow absorption is perhaps an advantage, as the local effect is prolonged a benefit if several months are required to complete the infiltration of multiple lesions. In patients with a tendency to keloid formation intradermal injections are less likely to cause this condition if oil is used for infiltration and not esters. The oil is more stable and when stored takes longer to undergo physical or chemical change and become irritant, especially if creosote has been added its cost is much less, a distinct advantage where large numbers of poor patients have to be treated. It is uncertain whether the oil or the esters is more effective if there is a difference it is not great. (*See* Appendix I)

Sodium hydnocarpate, though it is considered less beneficial than the oil or esters, has the advantage of cheapness and of being preserved in powder form. It is given as a 3 per cent solution in water

Methods of Injection.—Which method—intramuscular subcutaneous, or intradermal—should be used depends on the type of case and the condition of the patient Sodium hynocarpate may be given intravenously but neither the oil nor the esters should be given by that route

Intramuscular injections can be given into any thick muscular mass, but the gluteus maximus is the muscle of choice. Each dose should be divided, not more than 1 c c being injected at any one point. Divided injections may be given by partly withdrawing the needle and reinserting it at different angles. By warming the oil and injecting slowly and dividing the dose hard and painful lumps and abscesses may be avoided If an attack of coughing comes on during an injection it is a sign that a vein has been pierced. This infrequent accident may be avoided by first pulling on the piston to see if blood enters the syringe.

Subcutaneous injections may be given under lesions occurring in fleshy parts of the body and especially on extensor surfaces

(*Fig* 10) The dose should be divided and other precautions taken as in the intramuscular method.

The *intradermal method* has the advantage that in addition to the general effect there is a local action on the lesion infiltrated this is easily demonstrated by infiltrating some lesions and leaving others as controls Intradermal injections while they may be used in all forms of lesions, are particularly suitable for leprides, as the margins are clearly defined and anæsthesia in proportion as it is present, relieves what would otherwise be a painful process

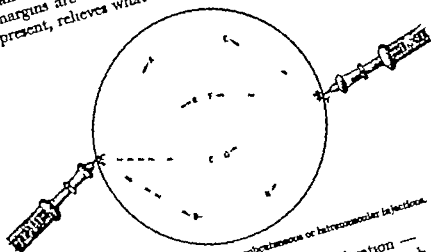


Fig 10.—Dividing the dose in giving subcutaneous or intramuscular injections.

There are two methods of intradermal infiltration —

a. The plancha of the Philippine workers, by which multiple small fractional doses of 0·05 to 0·1 c c. are injected into (not under) the skin, a small wheal of about 5 mm diameter being raised round each puncture In this way an area up to 36 sq cm. or more may be infiltrated at one sitting A short needle which can only enter the skin about 2 or 3 mm. is convenient for rapid injection. Care must be taken not to pierce the subcutaneous tissue (*See Figs* 85 86)

b A long thin needle is threaded through the skin to its socket and the oil or esters are injected as the needle is withdrawn Care is taken not to button-hole the skin or to go too deep The successful injection should leave a long wheal along the track of the needle.

There should be no reinfiltration of an area of skin for at least a month or till all induration caused by the last injection has resolved. In the case of nodules or other lesions penetrating the subcutaneous tissue infiltration must be proportionately deep

The rationale of intradermal injections is that the infiltrated oil stimulates the multiplication and activity of phagocytic cells in the cutis and these again ingest and destroy the bacilli in their neighbourhood Where there are large or numerous lepride it is well to begin treatment by injecting round the spreading edge, the needle being inserted just inside the anæsthetic margin but the oil being infiltrated so as to spread beyond the margin In this way it is generally possible to arrest the spreading infection just as a bush fire may be arrested by tracing a line of fire across its advancing path

Dosage—The tolerance of the patient to hydnocarpus oil and esters varies with the weight age and general health of the patient. Each injection produces a negative phase, the degree and duration of which are relative to the condition of the patient. The more physically fit he is and the firmer his muscles the larger the doses he will tolerate On the other hand even the smallest doses may not be tolerated by weak patients and may cause exacerbation

In estimating the tolerance of the patient the *blood sedimentation test* is of great value, a high sedimentation index being a sign either to delay further injections or to diminish the dose. Any uncomplicated instrument, such as the Westergren or the very simple and rapid micro-sedimentation apparatus, may be used. The more complicated forms, such as those that take anæmia into consideration, are unnecessary in leprosy as patients with a low sedimentation index are not anæmic, and it is only these in whom the special treatment should be pressed. In cases in which good general health has not been established the test should be repeated once a week or at least once a fortnight. (*See also* p 231)

The usual dose of the oil, hydnocarpate (Alepol) or esters is from 0·5 to 6 c.c. once or twice weekly It is well to begin with small doses and gradually increase the amount as tolerance permits. In many cases a proportion is given intradermally and the balance by the other method

SUPPLEMENTARY TREATMENT

1 **Trichloracetic Acid.**—A 1–3 solution of this acid in distilled water is a useful caustic for application to leprides or diffuse leproma. The skin should first be cleansed of grease the solution is painted on an area or areas comprising up to 100 sq cm. or more if on drying uniform slight whitening of the painted surface does not appear the process must be repeated. Care must be taken not to overdo this and cause ulceration the cauterized areas should be painted with bland oil or protected with lint

soaked in oil. Application should be made to successive areas once a week, but an area should not be repainted until it has desquamated and lost all signs of irritation A 1–1 solution of acid may be applied to nodules and other thick areas. This treatment may be combined with intradermal injections, the area injected being painted with acid on the following week.

The action of caustics and local applications is not known, but they probably act by stimulating phagocytic action and causing the destruction of bacilli and resolution of the underlying lesion. Hot baths, intermittent pressure by strapping rubbing with oil, and various local applications are of value in causing absorption and in protecting the skin from secondary infections.

2. Removal of Nodules.—These may be removed by the application of CO_2 snow A pencil of this substance is pressed against the nodule for 15 to 30 seconds. Several applications at intervals of one or two weeks may be necessary to cause complete disappearance.

An easier and more rapid method is abrasion. The area, whether a single nodule or a nodular area is infiltrated round the margin with a 1 per cent solution of novocain containing 5 to 10 min. of adrenaline. In trimming the ears and where else practicable a clamp may be applied so as to fix the part and further prevent bleeding The nodules are shaved off with a safety razor blade held with a pair of artery forceps. Pure carbolic is applied to the raw surface before removing the clamp In most cases the only dressing required is a very thin layer of dry sterile cotton wool Occasionally in abrading the ear one or two stitches may be necessary to stop bleeding These procedures, while not eradicating the disease, may considerably improve the appearance of the patient, and promote healing

3. Excision of Lesions.—The wisdom of an attempt to eradicate leprosy by excision is very doubtful. As a lepromatous lesion implies generalization of the disease it is only in a strictly localized lepride that the attempt could be successful. But such a lepride can much more easily and probably more effectively be dealt with by intradermal injections of hydnocarpus oil.

SIGNS OF ACTIVITY

Before considering the duration of treatment it is important to recognize the signs *of activity of the disease* The most important of these is positive bacteriological findings, but in the large group of cases in which from the beginning these findings

have been negative the difference between active and residual signs must be recognized clinically alone

In leprides, whether simple or tuberculoid growth in size necessarily indicates activity but as this may be slow or intermittent other indications must be sought. The presence of anaesthesia cannot be relied upon as this persists in residual areas In most leprides there is a tendency to resolution at the centre and accordingly it is at the margin that active signs should be sought. These are elevation above the surrounding skin redness and vascular congestion, and irregular shape caused by extension of pseudopodia. All these disappear in residual lesions

Many polyneuritic lesions are of a residual nature Contractures and trophic ulcers may first appear or increase after infection has been eradicated due to the shrinking of newly formed intraneural fibrous tissue which constricts the nerve-fibres supplying the extremities and other parts In such cases the sign of activity is the persistence of thickening and tenderness in the main nerves, especially those which supply the hands and feet.

DURATION OF TREATMENT

In early neural cases where the disease is definitely limited to a few small leprides and there is no sign of thickening or tenderness of the main nerves or of secondary polyneuritic lesions a few courses (1 to 6) of intradermal injections of chaulmoogra oil or its derivatives should be sufficient to clear up the disease, and the whole treatment may be completed in a few weeks time. Such patients should however be kept under observation for one or two years in case fresh lesions appear

Generally speaking special treatment should continue till all active signs have disappeared, that is, till repeated bacteriological examinations of skin and nose are negative, all leprides have become residual and nerves are no longer thick and tender There are, however certain factors which call for modification of this rule. In patients in whom some definite depressing factor was responsible for the development and progress of the disease, removal of this may so facilitate improvement that treatment may be stopped earlier the patient reporting from time to time for examination as to progress. On the other hand, patients who have become free from all active signs, but whose general health is not of a high standard also those who on returning to unfavourable home circumstances from an institution would become depressed should continue in the institution under treatment for a longer time to avoid relapse When active signs have definitely

gone the disease is said to be quiescent and check of periodical examinations it has continu two years it is considered arrested In many cases, however it is advisable to keep the patient u for a much longer period, warning him that any tion of health may be followed by a relapse, and picious signs of recurrence appear he should report

SELECTION OF CASES FOR TREAT

We have often had most disappointing results leper institutions where treatment has been tried tion of these reports has led us to the conclusion the cases had not been wisely chosen. It is useless to that have little more than permanent nerve lesions may have healed up to a large extent, their nerves hav fibrosed trophic ulcers have formed which require but which no amount of special treatment with chaulm be expected to improve.

Special treatment is aimed at the destruction of lep but, when these have practically died out of the body the ties and scars which are left can only be palliated and the of such permanent lesions can never be restored.

Again there are cases which are permanently debilitated whom general treatment has failed to improve the general such patients are usually quite unsuitable for special treatm

Compulsion should never be used Unless patients ar pared to enter heart and soul into the treatment and do part to make it successful, there is little hope of benefiting Many of the inmates of leper institutions have long ago lo hope of recovery and have given themselves up to the ide being lepers for the rest of their lives In such cases only pallia measures are of use and any attempt to use force will only b discredit on the treatment

On the other hand we have found that, wherever in any cen treatment of lepers has been carried out intelligently along t lines which we have indicated, the majority of those sufferin from leprosy have been attracted and there has been no need f compulsion (p 128)

Patients should be encouraged to come as early as possible and they should always be warned from the very outset that the treat nent must necessarily be protracted and that the chance of final ecovery must depend to a large extent on the energy and persev nce with which they carry out their part.

TREATMENT OF LEPRA REACTION

The treatment of lepra reaction depends on its cause. If it is the result of excessive special treatment, then this must be stopped If it is from a complicating disease like malaria this must be diagnosed and treated In other cases a vicious circle is formed, the depression of health caused by the reactionary phase being sufficient to prevent its subsiding It is necessary therefore in addition to removing the cause to take special means to desensitize the patient

He should be confined to bed and the bowels freely evacuated Alkalis are given in the form of sodium bicarbonate 4 g orally four times a day Potassium antimony tartrate 0·02 to 0·04 g dissolved in 2 c.c. of saline given intravenously three times a week is one of the most effective desensitizers If this fails mercurochrome (1 c.c rising to 10 c c. of a 1 per cent freshly made solution given thrice a week) may control the condition Calcium in large doses has also been found useful Fluorescein, trypan blue, methylene blue, and other dyes have also been used with success in some cases, as have also gold (krysolgan, sanocrysin etc.) copper and other heavy metals When dyes and heavy metals are used it is important to confine their use to small amounts, as excessive doses tend to produce the opposite effect and increase the reaction. Their use should not be continued for more than one or two weeks Many painful and deforming nerve reactions may be relieved by operation (*See* REGIONAL TREATMENT p 256)

In severe cases of prolonged reaction with chronic ulcerating lesions secondary anæmia is often present (*see* p 187) Care must be taken in the administration of large doses of iron as this sometimes causes exacerbation. Much benefit is generally derived from the use of liver extracts especially when given by injection.

TREATMENT OF PAIN

The treatment will depend to a certain extent on the seat and the cause of the pain Sudden increase of pain or tenderness of nerves is generally associated with lepra reaction. *Adrenaline hydrochloride* 1–1000 solution (0·2 to 0·3 c.c in 5 c.c of saline) infiltrated into the subcutaneous tissue round a tender nerve or 0·02 g of *ephedrine sulphate* either orally or infiltrated round the nerve (dissolved in 10 c.c of 0·5 per cent sodium bicarbonate solution) will often cause immediate relief Recently small doses of venom (1 to 3 mouse units) have been found useful in relieving nerve and other pains in leprosy

Keil recommends intramuscular injections of synthetic vitamin B_1 (Betaxin) in leprous neuritis with swelling of the hands and feet. He

gave 1 mg doses to a total of 45 mg in 9 weeks. Symptoms [illegible] appeared quickly These results have been confirmed by other[illegible]

Diathermy skilfully applied may relieve nerve pains. So[illegible] times surgical interference is necessary to relieve constriction [illegible] nerves (p 257)

Pains in the bones especially at the ends of the long bones, [illegible] common symptom in advanced lepromatous cases especial[illegible] in a debilitated condition These may be relieved by alkal[illegible] sodium salicylate, cobra venom, and other drugs but it is ofte[illegible] difficult to do more than palliate the condition unless it is possible to improve the general health.

REGIONAL TREATMENT

1 **Perforating Ulcers.**—Treatment of these is one of the hardest problems in leprosy Chronic ulcers with little discharge, surrounded by thickened epithelium may be stimulated by infiltrating the subcutaneous tissue immediately round the ulcer with hydnocarpus esters or a mildly irritant antiseptic. Septic conditions clear up with intramuscular injection of 10 c.c. of soluseptasine (Germond 1940) Then in large ulcers, a mixture of suet, clarified butter and beeswax (in the proportions of 8 4, and 1) may be poured on warm the solidified substance is carefully covered with a double dressing and left on for a fortnight. This form of dressing has the advantage of letting the patient walk about, though in some cases immobilization is necessary to secure healing

If there is dead bone no other treatment will cause healing till this has been removed (*see Figs* 74, 75) Sometimes amputation of a toe is sufficient but if a metatarsal is affected, as is frequently the case, this must be removed in whole or in part, and when in doubt it is better to remove too much than too little bone.

Metatarsectomy—As apart from small operations on fingers and toes this is perhaps the most frequent operation required in leprosy a detailed description may be useful Because of the natural absence of sensation a general anaesthetic is not necessary but in some cases it is well to infiltrate with a 1 per cent solution of novocain and adrenaline half an hour before the operation. After the parts have been cleaned and iodine applied a tourniquet is applied round the middle of the thigh. An incision down to the metatarsus is made on its plantar surface along its whole length and the superficial structures are separated from the bone by [illegible] of knife or scissors. The bone is then removed piecemeal [illegible] prefer- ence a small pair of cuttin[illegible] rceps. The ed[illegible] ound are trimmed and brough[illegible] s far as poss[illegible] ning

PLATES

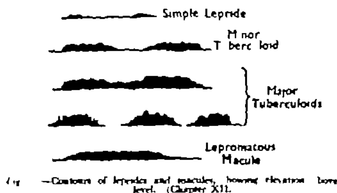


Fig. —Contours of leprides and macules, showing elevation above level. (Chapter XII.

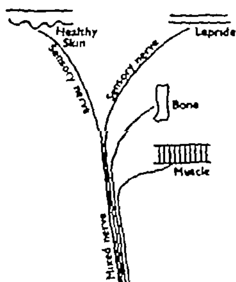


Fig. 2.—Diagram illustrating how infection spreads to the main nerves [illegible] causes secondary [illegible] lesions of the hands and feet. (See pp. 76, [illegible]



Fig. 3.—Leprous parents and child showing how leprosy is spread. (See pp. 19–33.)



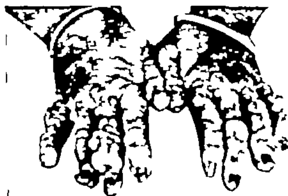
Fig. 4.—Nodulation of palms in lepromatous type. (See pp. 9 98.)



Fig —Lepromatous type uh deep infiltration



Fig 6.—Extreme nodulation of the face and arms. The trunk though apparently healthy d f finely infiltrated.



F 7 E treme sarcoid-like nodulation f finger



Fig. 8.



Fig. 9.

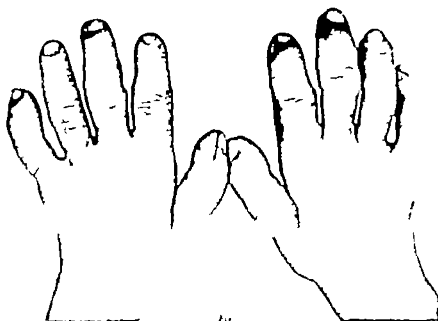
Figs. 8, 9.—During and after lepra reaction. (See p. 87.)



F 20



F



Fig

Figs. 20–22.—Lepr[illegible] reaction, generalized in *Fig.* [illegible] but localized to the face and to the fingers in the other two. (See p. [illegible]7.)



Fig. 23.—Symmetric thickening of ears in lepromatous type, cf. *Fig.* 34. (*See* p. 83.)



Fig. 24.—Scattered lepromatous nodules on diffusely infiltrated skin.



Fig. 25.—Cracked-paper appearance after resolution. (*See* p. 205.)



Fig. 26.—Resolution stage. Note deflated appearance of face and ears. (See p. [illegible].)

F[illegible] Scars of old rash (nodules). (See p. [illegible].)



Fig. 28.—Dermal leishmanoids of kala azar resembling leprosy (*See* p. [illegible].)



Fig. 29.—Adenoma sebaceum et acanthoides cysticum resembling leprosy

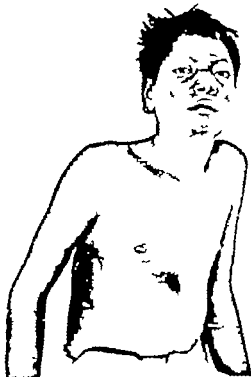


Fig. 90.—Sudden lepromatous eruption, corresponding to the distribution of an intercostal nerve. The posterior part of the lesion is not shown. (*See p.* [illegible].)



Fig. [illegible].—Elephant-like thickening in chronic lepromatous form. (See p. [illegible].)



Fig. 58.—Gynecomastia in three cases of the lepromatous type. (*See* p. [illegible].) Note also nasal condition. (*See* p. 98.)



Fig. 59.—Alopecia following lepromatous infiltration of the scalp. (*See* pp. 92 et seq.)



Fig. [illegible]



Fig 3. Typical facies of advanced nerve leprosy. Note paresis of the sphincters of eyes and mouth. There is also partial anaesthesia of the face and cornea. The patient [illegible] trying to close his eyes. There [illegible] ectropion of the lower lid. (See pp. 93, [illegible].)



Fig 36.—General lepromatous infiltration of thigh except inside rings which mark sites of former leprides. (*See* p. 83.)



Fig 37.—Tuberculoid lesions of the prepuce and scrotum. (*See* pp. 80, 203.)



Fig 38.—Hypopigmented macule with spreading margin and acute inflammatory reaction in form of ring of nodules and papules inside the margin. (*See* p. 86.)



F[illegible] 39



Fig. 40.



Fig. [illegible]



F[illegible] 4[illegible]

Figs. 39 [illegible] —A[illegible] simple lesion [illegible] with [illegible] hypopigmentation and irregular spreading margins. (See pp. 79, 8[illegible].)

Fig. [illegible] —Tinea fla[illegible] resembling simple leprides. (See p. [illegible]3.)



Fig. 4 —Superficial pebbled form of tuberculoid leprides. (See pp. 44 80)



Fig. 44.—Tinea flava resembling simple leprides but unlike the latter originating [illegible]



Fig. [illegible] Widespread [illegible] tuberculous lesions [illegible] h broad [illegible] See pp. [illegible] 86

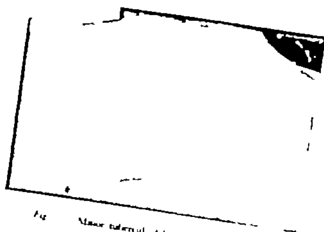


Fig. [illegible] Minor tubercul[illegible] les[illegible]



Fig. 47.—Tuberculoid lesions with thin active margin, and almost complete spontaneous healing of the central zones. (*See* p. 92.)

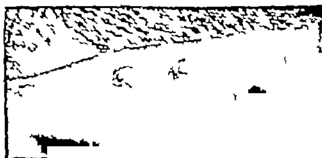


Fig. 48.—Natural leprosy. Nodules formed at sites of intradermal injections of lepromin. (*See* pp. 58, 85, 262.)



F[illegible] 49.—Compensatory hyperidrosis of the trunk in neural leprosy with anidrosis of the limbs [illegible] (See [illegible] ; [illegible] .)



Fig. 50.—Miliaria rubra, prickly heat, over the chest and abdomen caused by excessive sweating of the trunk [illegible] mild leprosy recognised only by its anidrosis and compensatory sweating [illegible] prickly heat. (See [illegible] [illegible].)



Fig 5 —Mask face and claw hands—residual lesions of the anaesthetic (poly-neuritic) subtype of neural leprosy (See pp. 93, 95, etc.)



F g 52 —Acute reaction in major tuber-culoid lesion of face. Note distinct margins of affected area. (See pp. 56 6 8 68.)



Fig 53 —Spontaneous healing with scar-formation following acute reaction in major tuberculoid.

[illegible] marking [illegible] reveals tubular leprous lesions [illegible] the [illegible] the back [illegible] side [illegible] the entire back [illegible] in its entire [illegible] the hand many [illegible] regular [illegible] the shape of [illegible] earlier [illegible] Lesions are conspicuously asymmetrical.



Fig. 35.—Widespread, asymmetrical, major tuberculoid lesions in acute reaction, with breaking down of epithelium and discharge of numerous bacilli. (See pp. 57 [illegible] 88, 134, 160.)

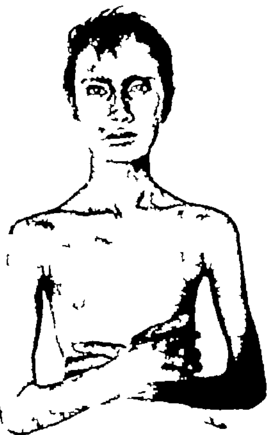


Fig. [illegible].—The same patient [illegible] months later. Residual, bacteriologically negative depigmented scars mark the sites of recent lesions.



Fig. 57. — Reacting multiple tuberculoid lesions of unusual form. (See pp. 60, 88.)



Fig. 58. — Dormant lesions superficially resembling those in Fig. 53. (See p. 23.)



Fig. 59. — [illegible] Africa, keloid often results from [illegible] applications of caustics, and occasionally [illegible] intradermal injections of esters. (See p. 250.)

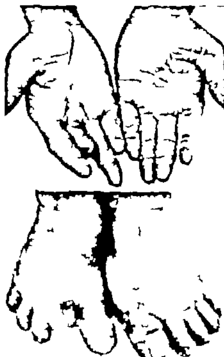


Fig. 60. — Non-leprous shortening of the fingers and toes in [illegible] leper [illegible] chiggers. (See p. 26.)



Fig 5.—Leprous lesion of the right supra-orbital nerve followed by paresis of part of the occipito-frontalis. (*See* p. 93.)



Fig. 6a.—Shortening of digits in the neural type. (*See* pp. 98–101.)



Fig. 63



Fig.

... photographs of hand and foot showing ... tion of bone.
(p. ...)



Fig 65.—Major tuberculoid lepride of face with thickening of branches of the cervical plexus. (*See* pp. 8 84 91.)



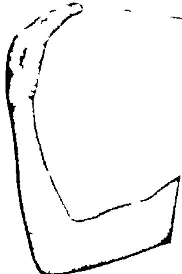
Fig 66.—Scar after metatarsectomy (*See* p. 236.)



Fig 67.—Tuberculoid of hand with thickening of branch of the radial nerve. (*See* pp. 84 85, 98.)



Fig 68.—Similar lesion of the foot with thickening of branch of the superficial peroneal nerve. (*See* 84, 85, 100.)



F[illegible] 6[illegible]. Liquefied [illegible] nodes of the ulnar nerve. (See pp. 84, 85.)



Fig. [illegible]. Abscess of the ulnar nerve, [illegible] Note thickened main nerve and branch.



F[illegible] 7[illegible].—Median cutaneous nerve of the [illegible] arm [illegible] series of [illegible] nodes, some having liquefied. (See pp. 84, 85.)

[illegible] in small doses have been found useful [illegible]

[illegible] method of relieving the very painful condition [illegible] the eye during lepra reaction is the sub-conjunctival [illegible] trypan blue in sterile [illegible] is prepared and kept [illegible] diluted 1–10 in the [illegible] and a speculum intro[illegible] forceps and, a fine [illegible] is inserted under the [illegible] and a few drops of the [illegible] the whole bulbar conjunctiva is [illegible] be a little burning sensation for a [illegible] very marked and in most cases [illegible] may have to be [illegible] In some cases the lepromatous invasion [illegible] slowed down by this pro[illegible] have recently been [illegible] conditions (pp. 244, 245)

[illegible] the improvement of the [illegible] the eye infection is [illegible]

[illegible] in which there is anaesthesia of the [illegible] and lagophthalmia, [illegible] it tends to become dry [illegible] Liquid paraffin should [illegible] during the day and a [illegible] be tied over the eye [illegible] orbit and intradermal [illegible] region will [illegible] extent in early [illegible] tarsor[illegible] close the [illegible]



Fig 65.—[illegible] with thickening [illegible] (See pp. 8[illegible] 84 [illegible])



Fig 67.—T[illegible]berculoid of hand with thickening of [illegible] branch of the radial nerve. (See pp. 84, 85, 98)

thick [illegible] nerve.



Fig. 72.



Fig. 73.

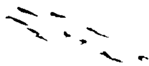


Fig. 74.

Figs. 72, 73, 74.—Chronic ya[illegible] lesions resembling leprides. Note also naevus in *Fig.* 72. (*See* p. [illegible].)



7 — Mycobacterium leprae ... grams partially stained forms. (See pp. 38 ... 8



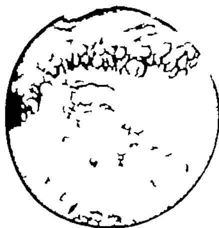


Fig. 77 — Skin section showing ... cells in cells of superficial spreading lepromatous macule. Capillary with numerous bacilli ... epithelium.

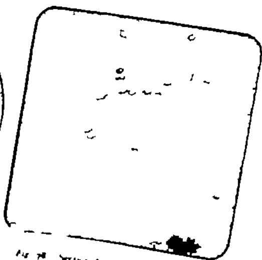


Fig. 78 — Section from tuberculoid skin lesion. Large multinuclear giant ... cell surrounded by epithelioid cells ... See p.



FIG. 79.—Section of nerve branch in the lepromatous type. Note clumps of bacilli lying between nerve-fibres and absence of destruction of nerve-fibres. (See pp. 78, 84.)

FIG. 80.—Section of tuberculoid lesion. Note the dense follicular nature of the cellular infiltration. (See pp. 62, 63.)



Fig. 8



Fi[illegible] 8



F[illegible] 83

Figs. 8 82.—*Hydnocarpus* [illegible] tree and [illegible] fruit (S[illegible])
Fig. 83.—*Hydnocarpus* [illegible] fruit and le[illegible]es (S[illegible])



Fig. 84.—Pulp and seeds of *Hydnocarpus anthelmintica*



Fig. 85.—Skin infiltrated with hydnocarpus oil by plancha or by the long needle method. (*See* p. 50.) Note conspicuous skin markings.

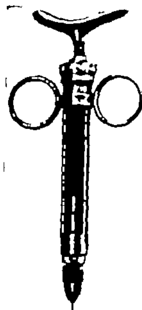


Fig. 86.—Syringe and needle suitable for plancha method of injection.



Fig. 8 —A stage of lepromatous leprosy, from which recovery [illegible] non. (See pp. 76, 77 [illegible] 3.)



F[illegible] 8B —The same patient bacteriologically negative after many [illegible] of treatment

being used to facilitate this when necessary Sulphathiazole or similar powder is rubbed into the wound which is then stuffed fairly tightly with sterile gauze and stitched with silk. In bandaging, sufficient pressure is applied to prevent hæmorrhage. It is unnecessary to ligature vessels and in this way much time is saved The tourniquet is removed after applying the first few tight rounds of the bandage. The first dressing is changed after forty-eight hours, and a small gauze wick impregnated with the same powder is introduced at this and subsequent dressings. The wound generally heals in three or four weeks. After the first week the patient should keep up his strength by walking with the aid of crutches but care must be taken that he does not apply his operated foot to the ground for several weeks after the wound has entirely healed This gives the parts time to consolidate, otherwise the wound may break down and form an ulcer again.

Sympathectomy has been tried in some cases, with doubtful results. Amputation is seldom necessary except in badly neglected cases.

It is important that perforating ulcers be healed up with as little delay as possible, either by some of the milder remedies or if these fail, by radical excision of bone. Otherwise, patients are apt to be demobilized, the general health deteriorates, and the disease as a whole becomes worse.

2. Conservative Operations on Nerves.—In carefully selected cases they are useful Nerve-stretching is always harmful. When a thickened ulnar nerve is constricted by dense fibrous tissue behind the elbow or the superficial peroneal at the head of the fibula, the constricting fibrous tissue should be severed. Complete removal of a portion of the nerve-sheath is recommended by Lowe, but this operation should be confined to cases in which thickening and inflammation of the nerve is marked, but is of relatively short duration, and in which deformity of the hand has either not yet developed or else is slight. A less radical operation is to slit the nerve-sheath without removing it. Cold abscesses of the nerves should be incised and the contents scraped out drainage of these is seldom necessary (*see Figs* 69, 70 71)

3. The Eye.—In leprotic invasion of the eyeball there may be considerable involvement of the eye without any inconvenience or obvious clinical signs It is well to test with atropine all cases with leprotic lesions of the face or nose. If there is any sign of fixation or irregular dilatation mydriatics should be given occasionally to prevent further fixation. In giving special treatment to patients with eye lesions particular care should be taken to avoid reactions, for these are often disastrous to the eye

preparations (as krysolgan) in small doses have been found useful in some cases

An effective method of relieving the very painful condition produced in the eye during lepra reaction is the sub-conjunctival infiltration of a 1–1000 suspension of trypan blue in sterile normal saline A 1 per cent suspension is prepared and kept ready for use. When required this is diluted 1–10 in the syringe The eye is carefully cocainized and a speculum introduced The conjunctiva is held with fixation forceps and a fine hypodermic needle being used, its point is inserted under the conjunctiva at several points in succession and a few drops of the fluid introduced at each till the whole bulbar conjunctiva is ballooned up There may be a little burning sensation for a short time but the relief of pain is very marked and in most cases continues permanently though the infiltration may have to be repeated in a few cases. In some cases the lepromatous invasion of the eye may be arrested or at least slowed down by this procedure Promin diasone, and penicillin have recently been found very useful in arresting eye conditions (pp 244, 245)

The best permanent results are from the improvement of the patient's general condition apart from this the eye infection is liable to be progressive

In cases of the neural type in which there is anæsthesia of the cornea, paresis of the lower lid ectropion, and lagophthalmus, the eyeball needs protection otherwise it tends to become dry and exposed to injury and may ulcerate. Liquid paraffin should be dropped between the lids frequently during the day and a pledget of cotton wool soaked in it should be tied over the eye at night. Massage of the face around the orbit and intradermal infiltration of chaulmoogra esters in the periorbital region will often restore the function of the eyelids to a certain extent in early cases. The condition may be improved by a marginal tarsorrhaphy or other plastic operation which will partially close the palpebral cleft.

4. The Nose and Respiratory Passages.—Discharge from the nose is probably one of the most dangerous sources of infection. It is therefore important that special treatment be given to render it bacteriologically negative. After removing crusts and anæsthetizing with cocaine and adrenaline, apply through a speculum some form of caustic such as trichloracetic acid or chromic acid (1–10 solution) or the mucous membrane may be fulgurated with an insulated unipolar electrode from a diathermy apparatus Douching with 2 per cent sodium bicarbonate solution

followed by a chloretone spray or painting with iodized hydnocarpus esters has been found useful

Blocking of the nasal passages is one of the most distressing conditions in leprosy In many cases this can be relieved by inserting a pledget of cotton-wool wound on a match-stick into each of the nasal passages The pledget should be as thick as can be inserted with slight force, and it should be soaked in adrenaline or ephedrine solution Daily dilatation in this way should be continued for some weeks. If this is not sufficient the passages should be cocainized and graduated silver bougies inserted

When these measures do not give relief it is necessary to excise the lepromatous growth lining the passages Pledgets of cotton wool soaked in 2 per cent cocaine are inserted for 15 minutes then after inserting a speculum 1 per cent novocain with adrenaline is injected into the tissues surrounding the obstruction After half an hour the obstruction is removed by paring round the passage with a narrow sharp knife After bleeding is prevented by stuffing with adrenaline swabs, and the nose is irrigated daily till the wound heals Eye inflammation not uncommonly accompanies nasal obstruction and is relieved after the above operation

As a preventive measure before extensive intranasal ulceration takes place, daily irrigation with salt water is useful. When practicable in warm climates this may be done by immersing the head while sea-bathing Another method is for the patient to lie on his back with a hard pillow under the chest, so that the nasal openings are horizontal. Sterile saline with 2 per cent ephedrine is dropped into the nose with a pipette while the patient breathes through the mouth. After a minute's interval the patient blocks the nasal opening by grasping it between finger and thumb and inhales strongly thus causing a vacuum in the nasal sinuses On freeing the nose the fluid is sucked into the sinuses, which it cleanses, and then is gradually expelled

For the effects of *diasone* and *promin* on the nose *see* p 244.

Tracheotomy is occasionally necessary to relieve dyspnoea caused by swelling of leprous lesions of the trachea or larynx. Rapid or slow asphyxia is a not uncommon cause of death in cases where the upper respiratory passages are seriously involved When such cases have spasmodic attacks of dyspnoea or show signs of general wasting the possibility of the need for tracheotomy should be considered. Marked improvement may follow this operation Granulomatous ulcers of the palate and fauces may be treated by painting with a caustic such as trichloracetic acid (1-10 solution)

5. Deformity of the Hands and Feet.—Carefully planned and regular exercises can often prevent or lessen deformity Such exercises may be supplied by employment in agriculture or industries, by using a typewriter or playing a musical instrument, or by drill parades.

ESTIMATING RESULTS OF TREATMENT

The reports published of treatment results in different places vary tremendously and the discrepancies are at first sight difficult to account for Some institutions publish high and others low percentages of recovery These depend to a certain extent on the type and degree of advancement of the cases admitted. Obviously in an institution where the majority are early neural cases, which will recover in a few months under intradermal injections, the figures will be much better than in an institution where the majority are more or less advanced lepromatous cases. Therefore, in evaluating treatment results, correct typing is important. (*See* Chapter XI)

The effect, too of a voluntary system with whole hearted co-operation of the patients is much better than that of compulsion. The climate, healthiness of the locality and many other matters mentioned above all tend to influence the effects obtained. Not the least important are the skill, sympathy and individual care expended by the physician on each case.

It has also to be remembered that appearances of improvement are often deceptive. The flattening out or disappearance of nodules or macules and the lessening of anaesthesia and trophic disturbances may be due to one of two causes the elimination of lepra bacilli from the tissues, or the lowering of the power of the tissues to react to the bacilli. The former denotes improvement, the latter deterioration. Frequently both physician and patient are deceived when an intercurrent disease lowers the resistance and the reacting power and a temporary fallacious appearance of improvement occurs

The reacting major tuberculoid mentioned above is another source of fallacy Whatever treatment had been administered is often given credit for recovery from a condition which not infrequently resolves spontaneously (*See Figs* 18, 19 53 55, 56)

Great caution is therefore necessary in evaluating one's own results or in accepting the reports of others yet with skill and patience it is often possible to obtain good results, as is shown in Chapter XVI under PROGNOSIS.

APPENDICES

APPENDIX I

PREPARATION OF ESTERS

For those who desire to use the esters, there are two methods recommended for their preparation —

1. **Cold Process.**—425 g of crude cold hydnocarpus oil 550 c.c. of 96 per cent ethyl alcohol, and 32 c.c. of sulphuric acid (sp. gr 1 845) are placed in a bottle with a tight fitting glass stopper and left until the process of esterification is complete. The bottle should be shaken once or twice a day to mix the upper and lower layers. This hastens the process, as does also the placing of the bottle in the sun or in some warm place. Neither the shaking nor the heat is, however essential if time is not a consideration. To begin with the oil forms a lower and the alcohol and acid an upper layer As esterification proceeds a point is reached at which the lower layer now chiefly composed of esters, gains a lower specific gravity than the upper layer which now contains a large proportion of glycerol and the former therefore rises to the top. To ensure the completion of the esterification it is well to allow the process to continue further for the same time which elapsed between the mixing of the ingredients and the rising of the lower layer Thus if the lower layer takes 14 days to rise, the ingredients should be left in the bottle for 4 days longer If a sample from the upper layer dissolves completely in alcohol, it is a sign that esterification is complete, as alcohol completely dissolves esters, but not oil. The lower layer is then drawn off, and the upper layer is washed with an equal volume of water twice over or till the washing water is free from acid as tested for by litmus paper It is then washed with a 0·1 per cent solution of sodium hydrate in water which forms a thick emulsion crystals of common salt are gradually added in small quantities and brought in contact with the emulsion by slowly rotating the vessel so as to break the emulsion. On standing, the esters will rise to the top When this has taken place the lower layer is removed, and the upper layer consisting of esters, after being washed once more with distilled water is filtered through thick filter paper The esters, though now clear still contain a certain amount of fine emulsion, which makes them dark in colour This may be removed by drying on a water-bath for two or three hours, while stirring constantly with a glass rod. The esters are then filtered again and the process is complete

The esters may be washed in the same bottle in which they have been prepared by substituting for the glass stopper a cork perforated with two glass tubes, one two inches in length inserted flush with the inner end of the cork and fitted with a piece of rubber tubing compressed

with a spring clamp and the other reaching from the cork to the bottom of the bottle. By inverting the bottle the esters rise to the top and the lower layer may be drained off by opening the clamp or without inverting the bottle the lower layer may be syphoned off through the long glass tube.

A separating funnel is more convenient for separating and washing esters.

2. Hot Process.—The esters may be prepared much more rapidly by placing the ingredients in a flask over a water-bath arranged to maintain a constant level of water A reflux condenser is fitted into the mouth of the flask. The water in the water bath is kept at a temperature sufficient to maintain brisk boiling inside the flask. This is continued without stopping for 18 hours, when it will be found that esterification is complete Washing of the esters is then carried out as in the cold process.

The weight of the esters recovered is almost equal to that of the oil used

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APPENDIX II

LEPROMIN (MITSUDA) TEST

Preparation of Antigen.—Dharmendra has described the following method of obtaining lepra bacilli free from residual tissue and lipoids —

Pieces of lepromatous material usually nodules cut from ears, are ground up in chloroform with a glass pestle and mortar The chloroform is pipetted off The grinding in chloroform is repeated till a smear from the remaining tissue is almost free from bacilli. (About 50 c.c. of chloroform are necessary to extract almost all the bacilli from 2 g of lepromatous tissue.) All the lots of chloroform used in grinding are pooled, and the remaining tissue is discarded. A smear from the pooled lot of chloroform shows bacilli in very large numbers and the absence of any tissue.

"The chloroform is then completely evaporated over a water bath the residual substance consists of lipoids and bacilli. This residue is then suspended in ether and the ethereal suspension is centrifugalized at a low temperature at 3000 r p.m. (In a hot climate this is done in a refrigerator) The lipoids remain in the supernatant ether and the bacilli are deposited at the bottom. The ethereal extract is pipetted off. To remove the lipoids more completely the bacillary deposit is again suspended in ether the suspension centrifugalized, and the deposited bacilli separated and dried. The deposit forms a dry powder and smears made from it show only bacilli and no tissue.

This method makes it possible to obtain a standardized antigen, which was not possible with Mitsuda's original method of using a ground-up suspension of leproma.

Performing the Test.—1 mg of the dry powder is suspended in 1 c.c. of saline, and of this 0·2 c.c. is injected into the skin. The results are read at 24 hours, 48 hours, 1 week, and once weekly for several weeks, but the immediate result within 48 hours is generally sufficient.

APPENDIX III

IODIDE TEST

When a patient of the lepromatous type has reached a stage in which repeated bacteriological examinations of the skin and nasal mucosa give negative results, the iodide test is of considerable value. *It should only be used however in cases in which the general health is of a high standard and the sedimentation test gives uniformly satisfactory findings.* (See p. 253.)

A single dose of 2 g. potassium iodide is given in a glass of water at bedtime. This may cause one or more of the four following results: (1) The appearance of new, or the reappearance of old, cutaneous lesions. (2) Pain, tenderness, or swelling of nerves. (3) Rise of temperature and other general signs. (4) Increase in the rate of erythrocyte sedimentation.

If any of the four above-mentioned signs appear, the next dose of iodide should be delayed *till they have entirely subsided.* Any skin lesions which may appear should be examined for bacilli, and if these are found intradermal injections of chaulmoogra should be given locally until negative results are obtained. The same dose of iodide should then be repeated. If no signs of reaction appear, then increasing doses are given once a fortnight, viz., 4, 6, 8, 12, 16 g. These should always be diluted with two or three glasses of water.

Any sign of reaction is an indication for not increasing the dose and for delaying the next dose till *all* signs of reaction have disappeared.

The smaller amounts may produce catarrh and other signs of iodism, but these are generally absent when the larger amounts are given.

If any difficulty is experienced in swallowing a large quantity of iodide at one time, then it may be divided into two or three portions taken at half-hourly intervals. The maximum dose of 240 gr. should be repeated three times. Iodides tend to produce what may be regarded as a negative phase. The precautions mentioned above are intended to secure that administration of the drug is not repeated during this negative phase.

N.B.—Never give the next dose of iodide till the sedimentation index has subsided to (or below) normal. The test is unsuitable for neural cases.

APPENDIX IV

THE EPIDEMIOLOGY OF LEPROSY

Report of the Sub-Committee adopted by the International Congress of Leprosy, Cairo, 1938

INTRODUCTION

Incidence.—The incidence of leprosy should be taken as the number of cases per thousand of the total population. It must be specified upon what information the incidence is based. (1) This information must

include the total number of persons residing in the area under consideration. (2) The total number of persons examined must be stated any discrepancy between the total population and the number examined should be explained. (3) Cases in isolation should be assigned to the area in which they were living at the time they were isolated. (4) All cases of leprosy diagnosed as such by the examiner including quiescent and arrested cases, should be recorded.

Age Groups.—The following age grouping should be used 0–4, 5–9, 10–14, 15–19, 20–29 30–39, 40–49 50–59, and 60 or more years. A child is to be taken to mean any person falling within the first three age groups.

Sex Incidence.—By the sex incidence of leprosy is meant the number of male cases per thousand and the number of female cases per thousand of the male and female sections respectively of the population examined.

Types of Survey.—It is recognized that there are two main types of survey (1) Extensive or general, and (2) Intensive or particular

1 *Extensive or general surveys* Such surveys may be based upon the incidental examination of known cases of leprosy by officials and others, or upon the examination of certain groups, as for example, school children, prisoners, conscripts or upon the examination of contacts of known cases.

2 *Intensive or particular surveys* An intensive survey depends upon the complete examination of the entire population by a trained personnel. In reports of such surveys it should be stated whether the examinations were conducted in the clinic or in the persons own homes. [*See also* p 135]

MINIMAL EPIDEMIOLOGICAL DATA

The committee recommends that the information for standard epidemiological studies be recorded in two main groups (1) General and (2) Individual. The latter concerns both (a) all of the individuals in the area surveyed, and (b) the lepers and leper suspects.

1 **General Information.**—The following general information regarding the region and the people is required (a) Climate, meteorology and soils (b) Geography and topography (c) Racial groupings (d) General social and economic conditions (e) Diet (f) Housing and sanitation (g) Hygiene habits of the community (h) Clothing (i) Prevalent occupation (agriculture, fishing, etc.) (j) Prevalent diseases (epidemic or otherwise) (k) Birth-rate, death-rate, and infant mortality-rate when available (l) Density of population (m) History of leprosy in the community (n) Native folk-lore, traditions, customs, and superstitions regarding the disease.

2. **Information concerning Individuals.**—

Information regarding all Individuals Examined.—The following information is required for every individual in the area surveyed (a) Serial number of individual (b) House number (c) Name (d) Age (e) Sex (f) Race, caste, religion (g) Relationship to head of family (h) Physical examinations—malnutrition, skin diseases, other diseases including leprosy definite or suspect (for lepers and suspected lepers *see below*) (i) History of contact with lepers, as indicated below

Information regarding Lepers and Suspects.—The following information is required concerning lepers and suspected lepers (*a*) Previous illnesses (*b*) History of contact with leprosy—(i) Intrafamilial and/or household contact (bed contact, room contact house contact, including joint-family system) stating family relationship (ii) Extrafamilial (intimate or casual) (iii) Contact not known. (*c*) Contact period—(i) Time since first known contact (ii) Time since last known contact (iii) Duration of contact (iv) Contact continuous or intermittent. (*d*) Particulars about presumed source of infection. (*e*) Age at onset of first manifestation of leprosy (*f*) Course of disease. (*g*) Present status, description and type of disease, including site of initial lesion. (*h*) Laboratory findings, examination of smears and if possible of sections, and serological tests (*i*) Conclusion—(i) Leprosy definite (ii) Leprosy suspected.

METHOD OF CONDUCTING AN INTENSIVE SURVEY

It is essential that the area chosen for a survey be sharply delimited and if possible it should coincide with an administrative area. In brief, there may be said to be two steps in an intensive survey First, there must be a complete enumeration or census of the chosen area by a sanitary inspector or assistant, preferably someone with sufficient preliminary training in leprosy work to enable him to recognize obvious lesions of the disease. The second step is the careful examination of every individual in the area by a leprologist, and the recording of data on appropriate forms.

Preliminary Examination or Survey.—The enumerator should conduct a house-to-house census of the area, recording his findings in some type of census book or on family cards. The houses are to be given numbers and a map of the area should be drawn, roughly to scale, indicating streets, lanes, houses (with numbers) streams, public latrines, etc. It should be made the practice that the inspector see every individual, and that he do not record data on hearsay evidence.

Clinical Examinations.—After the preliminary survey has been completed the leprologist proceeds to examine all persons in the area. It is probably best to have some building near the centre of the area set aside for use as a clinic, where as many as possible of the population should be examined. In the examination the whole body should be inspected, the clothing having been removed, and when that is not done record should be made of that fact. The examiner's findings in each case are to be recorded in the survey book, and in addition, when leprosy is present or suspected, a separate examination form should be filled in. The preliminary data recorded by the inspector should be checked, and more detailed information obtained. With non-lepers, as well as with those suffering from the disease, an effort should be made to determine whether or not there has been any previous contact with lepers. When there has been such contact its time and duration as well as its nature should be ascertained. Such information is to be obtained by questioning, and from the records after the completion of the survey Its collection may present considerable difficulty

DERIVATION OF RATES

Certain leprosy indices which may be valuable can be derived from survey data. These are —

1. The *case-type rate* which is the number of open cases per 100 cases of leprosy

2. The *sex rate* which is the number of male lepers per 100 cases of leprosy

3. The *childhood rate* which is the number of child lepers per 100 cases of leprosy

4. The *contact rates* which are (a) The number of lepers with familial (household) contact per 100 cases of leprosy (b) The number of lepers with extrafamilial contact per 100 cases of leprosy (c) The number of lepers with contact unknown per 100 cases of leprosy

Further correlation, such as the ratio between case types and sex, etc., may be derived from these data at the discretion of the investigator

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